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INTERNATIONAL ENERGY AGENCY



TECHNOLOGY WITHOUT BORDERS



Case Studies
of Successful
Technology Transfer





INTERNATIONAL ENERGY AGENCY

TECHNOLOGY WITHOUT BORDERS

Case Studies
of Successful
Technology Transfer

INTERNATIONAL ENERGY AGENCY

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-five* of the OECD's thirty Member countries. The basic aims of the IEA are :

- To maintain and improve systems for coping with oil supply disruptions ;
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations ;
- To operate a permanent information system on the international oil market ;
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use ;
- To assist in the integration of environmental and energy policies.

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FOREWORD

We are undoubtedly living in the greatest period of technical innovation in the history of *Homo sapiens*. At the same time, more than a billion people live such impoverished lives that the thought of living with even the basic technical “necessities”, seems to them a pure and cruel hoax. How can such a technical inequality endure, particularly during a period of economic boom?

One of the answers to this confounding challenge lies in the transfer of technology from developed to developing countries. Although there is sometimes a tendency to think of this as a simple task, it is a complex process. Successful technology transfer requires the right “framework” to meet the needs and account for the capabilities of the recipient, the willingness of all involved to listen to each other and an attention to detail that is too often neglected or seen as the responsibility of some other party.

There is also the issue of transferring the most appropriate technology. This is particularly important in the serious issue of climate change.

The exhaustive study, released in 2000, by the Intergovernmental Panel on Climate Change on technology transfer and climate change concluded that stabilising concentrations of greenhouse gases requires technological innovation, followed by the widespread transfer of new technologies and skills within countries and across national borders – particularly from developed to developing countries, but also between developing countries.

New, climate-friendly technologies offer great promise, not only because they can help our societies reduce the emission of greenhouse gases. Renewable-energy systems and technologies that improve the efficiency with which we use energy can improve local and regional air quality, and reduce pressure on fragile ecosystems. Renewable energy offers an opportunity to bring electricity to rural areas in developing countries, giving millions of poor people a chance to improve their lives.

However, we should not think that technology transfer is just about helping developing countries. It is very much in the interests of developed countries to have a more stable atmosphere and less pollution – as these do not respect national boundaries.

Klaus Töpfer

Executive Director

United Nations Environment Programme

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INTRODUCTION

OBJECTIVE

Technology Without Borders presents case studies of successful transfer of climate-friendly technology and practices. It explores the causes for success and draws the lessons learned. Key messages are presented for the fight against climate destabilisation. The terms “climate-friendly technology” and “climate technology” used here refer to technologies, practices or techniques, which reduce greenhouse-gas emissions or assist countries in adapting to climate change.¹

WHAT IS TECHNOLOGY TRANSFER?

Technology transfer sounds simple. In reality, it is a highly complex process, influenced by domestic and international factors. Many players are involved, for example, in bringing solar panels to an African village or protecting the coast of an island in the South Pacific.

Technology transfer is *not* simply about the supply and shipment of hardware across international borders. It is about the complex process of sharing knowledge and adapting technology to meet local conditions. It strengthens human and technological capacity in developing countries. It promotes commercial markets for climate-friendly technology.

WHY IS CLIMATE-FRIENDLY TECHNOLOGY TRANSFER IMPORTANT?

Scientific evidence that greenhouse gases (GHGs) contribute to global climate change grows stronger year by year. Governments, as well as private firms, are beginning to take action to curb emissions. After more than two centuries of economic growth fuelled by the burning of fossil fuels the

¹ The United Nations Framework Convention on Climate Change refers to “environmentally-sound technologies and know-how”.

prospect of decarbonising Western economies is daunting indeed. The industrialised countries have expensive infrastructure based on fossil fuels and little experience with alternative technologies. Energy technologies are long-lived capital stock.

Developing countries and the economies in transition emit less GHGs per capita than do the industrialised countries. Based on current trends, however, emissions from these countries will soon be greater than those from the industrialised countries. By 2020, the International Energy Agency estimates, 60% of GHG emissions will come from the economies in transition and developing countries, up from 49% today.²

Developing countries need to “leapfrog” a technological generation or two if concentrations of GHGs are to be stabilised. Economic and social development inevitably leads to increased demand for energy services. In most industrialised countries these demands were met initially by coal and water power, then by oil, natural gas electric and nuclear power. We are now seeing the emergence of renewable-energy technologies. Developing countries’ infrastructure and economies are not as dependent on fossil fuels as the industrialised countries are. They can, therefore, avoid the fossil-fuel trap and move directly to environmentally-sound technologies.

Few countries will choose a more expensive technology if its only benefit is avoiding the potential adverse effects of climate change. Yet climate-friendly technology can provide associated benefits, such as reduced air and water pollution. But, an available clean technology is often passed over because of factors such as poor access to information or a lack of financing. Technical assistance programmes can help overcome these barriers.

TECHNOLOGY, ECONOMIES AND GREENHOUSE GASES

Technology is a critical factor in determining the real costs of economic and social development and environmental effects. A recent IPCC report explores future energy and environment scenarios and concludes that technology is at least as important in reducing emissions as demographic

2 International Energy Agency, 2000. *World Energy Outlook 2000 Edition*. Paris (France): IEA/OECD.

change and economic development.³ An IPCC report concludes that, regardless of other factors, the atmospheric concentration of GHGs can be stabilised at an appropriate level *only* with a significant shift in the patterns of technological development and diffusion.⁴

All nations should factor the development and diffusion of environmentally-sound technology into their investments in energy infrastructure.

TECHNOLOGY TRANSFER IN INTERNATIONAL AGREEMENTS

Reducing GHG emissions and providing aid to countries that are vulnerable to the effects of climate change are global environment and development priorities. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) provides a way for countries to address climate change issues. The central goal of the UNFCCC is to achieve “stabilisation of greenhouse gas concentrations in the atmosphere at such a level that would prevent dangerous interference with the climate system. Such a level should be achieved in a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner”.⁵

Conscious of the critical role of environmentally-sound technology in the development process, signatories to several international agreements have made specific commitments to support technology transfer. The UNFCCC and Agenda 21, a United Nations action plan for sustainable development, contain such provisions. Article 4.5 of the UNFCCC states that industrialised countries should “take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally-sound technologies and know-how to other Parties, particularly developing country Parties...”.⁶

Ratification of the UNFCCC obliges industrialised countries to assist developing countries to mitigate and adapt to the effects of climate change.

3 IPCC, 2000b. “Emissions Scenarios”, *A Special Report of Intergovernmental Panel on Climate Change Working Group III*. Cambridge (UK): Cambridge University Press.

4 IPCC, 2000a. “Methodological and Technological Issues in Technology Transfer”.

5 UNFCCC Article 2.

6 Other relevant UNFCCC Articles include 4.1, 4.3, 4.4 and 4.7.

But the commitments of Annex I countries to assist developing countries under the UNFCCC are sadly lacking in specifics.⁷ Chapter 34 of the UN's Agenda 21 provides some guidance on how participants can co-operate to accelerate technology transfer. Neither agreement provides a readily comprehensible strategy for action.

A key point in international climate-change negotiations has been how to distinguish between technology transfer efforts undertaken specifically to address UNFCCC commitments and technology transfer that would have taken place anyway.

In recent years, the World Bank and the Global Environment Facility (GEF) have started to include climate-relevant technology-transfer in their portfolios.⁸ But, energy projects financed by the World Bank and its private-sector lending arm, the International Finance Corporation (IFC), still go primarily for carbon-intensive power projects and large-scale hydropower projects.

The Kyoto Protocol

The Kyoto Protocol, an international agreement within the UNFCCC framework, was adopted in 1997. It will enter into force when ratified by 55 countries which together produce at least 55% of the total emissions from Annex I Parties. The Protocol requires Annex I countries to reduce their GHG emissions by an average of 5.1% from 1990 levels. It also requires Annex I countries to undertake climate-friendly technology transfer.

The international community's thinking on technology transfer is evolving. The Kyoto Protocol emphasises *co-operation* between industrialised and developing countries. It formally recognises the role of the private sector and the need for an "enabling environment" to promote investment.

Two specific mechanisms in the Kyoto Protocol could further accelerate the development and transfer of climate-friendly technologies. Projects under the Clean Development Mechanism (CDM) and Joint Implementation could advance technology transfer, but their effect will depend on still unsettled details. Under the CDM, investors in climate-friendly projects in

⁷ Annex I of this book Lists Annex I countries.

⁸ Information on the GEF climate change portfolio is contained in Martinot, E. and O. McDoom, 1999. *Promoting Energy Efficiency and Renewable Energy: GEF Climate Change Projects and Impacts*. Washington, D.C. (US): Global Environment Facility.

developing countries may be eligible for emission-reduction credits. Ratification of the Kyoto Protocol would stimulate markets for commercially viable clean technology.

WHO AND WHERE ARE THE PLAYERS IN TECHNOLOGY TRANSFER?

The participants in technology transfer include those involved in the direct transactions – private firms, state-owned companies and individual consumers. But others play important roles “behind the scenes” – financiers, aid agencies, national governments, international institutions and local community groups. Technology transfer works best when all stakeholders communicate and actively participate.

Local and regional governments are often well positioned to promote environmentally-sound technological development and diffusion through leading by example. Local governments can identify, and respond to local needs. It is difficult, however, to co-ordinate many decentralised government units. National governments can play a critical role in co-ordinating and setting policy, and providing legal and regulatory framework to encourage environmentally-sound technologies.

The private sector is responsible for most of the innovation, development and diffusion of technology. It also provides most of the capital through direct investment, commercial lending and equity investment. In some countries and in certain sectors, however, official development assistance forms the bulk of foreign capital flows.

Various barriers hinder or even prevent technology transfer altogether. International initiatives, such as the International Energy Agency’s GREENTIE and Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) and the United Nation Environment Programme’s OzonAction Clearinghouse, seek to overcome one very significant barrier: the lack of adequate information.⁹ Such initiatives co-ordinate information flow and research and development (R&D) by forming collaborative stakeholder networks.

9 <http://www.unepic.org/ozonaction.html>, <http://www.greentie.org> and <http://www.caddet.org>.

International efforts to promote environmentally-sound technologies focus on co-ordinating markets rather than driving them. This requires guiding the private sector and other interested parties, such as non-governmental organisations and universities. When policy-makers “pick favourites” by strongly supporting a specific technology, the result can be that an unviable technology is maintained at public expense while innovative technologies are held back. Providing opportunities for many new technologies allows the best of them to shine through.

GEOGRAPHIC COVERAGE

The scope for climate-technology diffusion is global; the applications are local. Case studies presented in this book are selected from four regions with economies that are developing or in transition: Latin American and the Caribbean, Africa, Asia/Pacific and Central and Eastern Europe.

ACCELERATING THE DIFFUSION OF CLIMATE-FRIENDLY TECHNOLOGY

A technology's successful diffusion depends not only on the value of the idea or innovation, but also on intertwined socio-economic, technological and political factors.

The main barriers to technology transfer are:¹⁰

- **Institutional:** inadequate legal and regulatory frameworks, insufficient assessment of technology needs and implementation plans.
- **Political:** instability and corruption.
- **Technological:** inadequate infrastructure, lack of technical standards and supporting institutions, low technical capabilities and technology knowledge base.
- **Economic:** instability, inappropriate subsidies, poor macro-economic conditions and non-transparent markets.
- **Information:** inadequate access to technical and financial information and poor dissemination of information to technology users.
- **Financial:** insufficient capital, financing instruments that favour traditional and large-scale projects, risks for foreign investors.
- **Cultural:** consumer preferences and social biases.
- **Legal:** uncertain ownership, lack of intellectual property-rights protection and unclear arbitration procedures.
- **Participation and consultation:** lack of local participation and inadequate understanding of local needs.

10 *Barriers and Opportunities Related to the Transfer of Technology*, FCCC/TP/1998/1.

Box 2.1

Practical Guidelines for Technology Transfer¹¹

Successful projects:

address an environmental problem... Does the project reduce GHG emissions or help countries adapt to the effects of climate change? Will the project improve other environmental or social problems?

...build the market for environmentally-sound technologies... It may “work” on a project level, but does it improve the technology’s ability to gain market share?

...are cost effective... Is the technology worth buying or investing in? Can efficient operation be maintained? Has it been evaluated on a life-cycle cost basis?

...stand a real chance in the real world... Is there enough accessible information about the technology? Is there adequate human, technological and institutional capacity to support a market in the technology? Is the technology politically acceptable? Is it replicable?

...and do not make other problems worse... Will it create new or exacerbate existing environmental or socio-economic problems?

REMOVE BARRIERS TO RELEASE POTENTIAL

Technologies and projects that meet the criteria in Box 2.1 have a good chance of creating a lasting market. In practice, however, successful technology transfer must overcome barriers.

Actions that foster a favourable environment for climate technology transfer, include:

building local skills: sharing information, and strengthening the technical capacity of the labour force;

engaging the private sector: creating a healthy business environment and providing incentives for clean technologies;

using development assistance effectively: enhancing government efforts to stimulate the market and improving co-ordination;

developing innovative financing: pooling resources and sharing risks.

11 IPCC, 2000a, “Methodological and Technological Issues in Technology Transfer”.

STRUCTURAL CHANGE IS NEEDED

Creating lasting markets for clean technologies is the ultimate goal. This is a large-scale, long-term task. Emissions offset by one-off aid projects will do little to stabilise concentrations of greenhouse gases in the atmosphere.

Climate-technology projects and programmes have both direct and indirect effects. The indirect effects usually appear as changes in markets and the altering of relationships among concerned parties over a long period of time and a wide geographical area. The design of a project *must* plan for these indirect effects.

BUILDING SKILLS, SHARING INFORMATION AND ASSESSING TECHNOLOGY NEEDS

CAPACITY BUILDING

Purchasing, shipping and installing environmentally-sound technology are only a few of the components of technology transfer. The process also requires the strengthening of technological, human and institutional capacity. Technology transfer may also include educating consumers, training workers, technical assistance and other “soft” activities that help developing countries incorporate and adapt new technologies and practices to meet local needs.

Specifics may include:

- training plant managers how to install, operate and maintain equipment;
- disseminating guidelines for power-system operators on how to deal with peak power demand when intermittent wind resources are brought on-line;
- holding workshops for government officials on how to develop a country’s technology-implementation plan;
- working with local banks on micro-credit lending;
- training salespeople to stress efficiency codes and labels.

Capacity building helps kick-start the creation of markets for climate-friendly technologies. As local skills improve, small and medium-size enterprises in a developing country increase their ability to attract foreign capital, technology and expertise and to conform to international standards. Foreign companies can then rely more on local firms.

Some developing countries are littered with useless, rusting “environmentally-friendly” hardware. This happens because the physical technology was not accompanied with the requisite capacity building. All the case studies in this book show that capacity building, in its many forms, is a crucial determinant for success.

- The activities of the Energy Efficiency Centres in Eastern Europe and in China have enhanced the host nations' ability to improve energy efficiency. The centres disseminate information to potential project developers and the public, help in initiating projects, conduct market analyses and identify options for projects and partners.
- The World Bank and Global Environment Facility (GEF) helped build the market for solar-energy systems for rural households in Sri Lanka. Their project emphasises local participation: local dealers assemble, sell and service the systems, using a combination of domestic and imported components. Local technicians have been trained, and consumers have been educated. Local micro-financing organisations provide consumer credit.
- The Hungary Energy Efficiency Co-financing Project builds Hungarian banks' experience with financing energy-efficiency projects. The project assumes some risk and gives technical assistance to local banks.
- A failed attempt to introduce vertical-shaft brick kilns in Bangladesh demonstrated the critical role of advice and training. In one case, an entrepreneur tried to build one of these kilns without adequate technical or financial assistance, but basic mistakes in the kiln's construction resulted in its failure. The technology was later successfully introduced in India, when an NGO set up a pilot project for the kilns in a controlled environment.

INFORMATION DISSEMINATION AND EDUCATION

Available information on climate-friendly technology is overwhelming in quantity and extremely uneven in quality. To complicate matters, nearly all sectors in the economy have the potential to reduce GHG emissions. The challenge is to get relevant and accurate information to the appropriate decision-makers. It will not be easy.

Some examples of effective information dissemination are:

- The Energy Efficiency Centres in countries with economies in transition disseminate information. They link companies in their region with those in industrialised countries and help clients negotiate contracts. They help companies analyse existing and potential markets and advise on how barriers can be overcome.

- The Chai Meng Project in Thailand demonstrated the profitability of rice-husk cogeneration. The EC-ASEAN COGEN programme acts as a conduit for information from European suppliers of biomass energy technologies to potential buyers in Asia.

Information is not, however, a panacea. Technology transfer works best when information dissemination, workforce training and consumer information work hand-in-hand. Illustrating the advantages of an environmentally-sound process or product in layman's terms can increase consumer demand. Workers need to be trained in safe and effective methods of operating new technology.

Information dissemination networks in developing countries are often underdeveloped and sometimes non-existent.

- The development of the photo-voltaic (PV) cell market in Kenya demonstrates the power of *informal* channels of communication. Most of the Kenyan PV market developed via word-of-mouth information. This method of information dissemination is well suited for rural communities and is inexpensive, but its limitations became apparent when false information prompted people to purchase inferior PV equipment. A combination of formal information dissemination and a product quality label are now being used to supplement the word-of-mouth approach.
- Consumer education was fundamental to the success of the Poland Efficient Lighting Project. Before the project, the public was unaware of the electricity savings that compact fluorescent lamps offer. The programme educated consumers about the lamps' cost-effectiveness, as well as their value to the environment.
- Pilot and demonstration projects can be a particularly effective way of disseminating technology information. The pilot plants used in the Indian Ecofrig project were a testing ground for the technologies and an information clearinghouse. Manufacturers interested in the technology can visit the pilot plants to gain experience and hear about lessons learned.

ASSESSING TECHNOLOGY NEEDS AND DEVELOPING TECHNOLOGY IMPLEMENTATION PLANS

Unique conditions in every country rule out any generic approach to technology transfer. Identifying the sectors of a country that would benefit most from a technology and selecting the most appropriate technology are the first steps in any technology-transfer initiative.

After assessing technology needs, a country can write a plan to deploy the technologies. A strategic long-term approach allows governments, industry and foreign technical assistance programmes to take action effectively.

A transparent and strategic technology-needs assessment and implementation plan can deliver benefits. A common approach is to:

- set up technical teams, to influence policy and practices;
- help government and the private sector identify promising technology areas;
- assist government in setting criteria for technology applications;
- stimulate private investment by collecting, distributing and analysing information;
- facilitate policy reforms to remove barriers to clean-technology deployment.

For example:

- Technology needs are assessed in the South African Solar Cooker Pilot Programme. The technology-needs assessment provided the German government with information on the deployment of solar cookers in South Africa. It also suggested improvements in the technology.
- The US Technology Co-operation Pilot Project (TCAPP) uses technology-needs assessments to determine appropriate technologies and to help governments target their policies to support priority technologies. Pilot projects are underway in Brazil, China, Egypt, Kazakhstan, Mexico, the Philippines, the Republic of Korea and South Africa.
- While the TCAPP approach is bilateral, the Climate Technology Initiative implements multilateral Co-operative Technology Implementation Plans. The advantages of a multilateral approach lie in increasing the pool of technologies, know-how and information available to developing countries.

Case Study

Global Competitiveness through Technology Upgrades: The Ecofrig Hydrocarbon Refrigerator in India

Project Characteristics

Type:	Hydrocarbon refrigeration
Location:	India
Financing:	Swiss Global Environment Fund, Swiss and German governments, Indian private industry partners
Developer:	INFRAS AG, a consulting group for environmental economics and policies

INTRODUCTION

Demonstrators in India hold a “refrigerator funeral” to accelerate the phase out of refrigerators that use CFCs.



The 1987 Montreal Protocol commits its 175 signatory countries to eliminate the use of ozone-depleting substances. Industrialised countries promised to phase out the use of these substances at various times throughout the mid 1990s. The target for developing countries is 2010.

India signed the Protocol in 1992. Its main challenge was to replace chlorofluorocarbons (CFCs), ozone depleting chemical compounds often used as refrigerants. Hydrocarbon (HC) technology and a compound called HFC134a were both identified as viable alternatives to CFCs, albeit with different benefits and drawbacks.

The Ecofrig Project has served as an information clearinghouse on alternative technologies to CFCs in the Indian refrigeration sector, and it complements global efforts such as UNEP's OzonAction Clearinghouse. It has boosted Indian expertise in household appliances in the areas of R&D, servicing and management.

GLOBALISATION AND CFC PHASE-OUT IN INDIA

India has seven main refrigerator manufacturers. Most have partnerships with multinational appliance manufacturers with corporate policies to phase-out CFCs.

The push to meet the Montreal Protocol deadline for industrialised countries has had its effect on developing countries, particularly those looking to expand their appliance export markets. To gain access to markets in industrialised countries, Indian appliance manufacturers must produce CFC-free refrigerators. This has accelerated the pace of the CFC phase-out in India.

The first Indian manufacturer switched to HC technology for its refrigerators in January 2001. Several others are now pilot-testing HC technology. Industry groups have submitted funding proposals to development banks to change their production lines to HC technology.

INFORMATION DISSEMINATION

To tackle the CFC challenge, Indian refrigerator manufacturers need accurate and unbiased information on alternative technologies. The Ecofrig project is providing the information and technical know-how to enable Indian manufacturers to make informed choices and to negotiate with technology suppliers in industrialised countries. Visits by Indian scientists, industry representatives and government officials to Swiss and German plants have helped India to understand the alternative technology. Information is also disseminated through workshops and reports on various aspects of the technology, including safety, performance tests, energy efficiency and planning.

CAPACITY BUILDING

Before Ecofrig began, the Indian refrigeration industry was not in a position to absorb the new eco-friendly technology. It lacked knowledge about new designs and different refrigerants, product-development capabilities and operating experience with the new technology. Proper facilities and equipment for servicing the new refrigerators were lacking, both in the formal and the “grey” sectors of the economy.

During Phase I of the project (1992-1997), two pilot plants were set up with two leading Indian refrigerator manufacturers. Technical know-how for appliance engineering, especially for the safe design of refrigerators based on HC refrigerants, came from Liebherr, a German appliance manufacturer.

Adopting Technology to the Indian Experience

The Ecofrig Project has achieved some success by taking account of Indian conditions. This in turn has led to strengthening capacity in domestic industries and research institutes.

Transfer of technical know-how for adaptive research, prototype development, testing and pilot production is taking place in the ongoing Phase II for HC-based compressors. It is expected that the participating Indian firms will manufacture their own state-of-the-art compressors based on HC technology rather than purchasing them, thus reducing their technology dependency.

Training the Servicing Sector

A study of the skills and knowledge required by servicing personnel identified barriers to the safe servicing of the HC technology. The project drew up a plan to train servicing personnel to safely deal with the technology.

As a parallel exercise to the Ecofrig Project, another initiative, called the Human and Institutional Development Project for Ecological Refrigeration, has been launched. It trains small and very-small enterprises in the service sector and carries out regular capacity building in the formal service sector.

LESSONS LEARNED

- A strong partnership between developing and developed countries was a key element in the success of the Ecofrig Project. This partnership allowed the Indian refrigeration industry to gain the knowledge required to select and adopt a suitable alternative technology.
- The emergence of commercial production of HC technology in India shows the effectiveness of the pilot-plant approach, functioning as both a testing ground and an information clearing house.
- This case underscores the importance of training in the service sector.

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Case Study

An Exercise in Capacity Building:

Project Characteristics

Type:	Energy Efficiency Centres (Not-for-Profit)
Locations:	Bulgaria, China, Czech Republic, Poland, Russia and Ukraine
Start-up funding:	US Environmental Protection Agency, US Department of Energy, US Agency for International Development, the World Wildlife Fund, the Charles Stewart Mott Foundation, and the John T. and Catherine T. MacArthur Foundation
Continued funding:	Self-sustaining
Developer:	US Pacific Northwest National Laboratory

INTRODUCTION



CENef's director, Igor Bashmakov, sealing a deal on energy-efficiency improvements

Between 1990 and 1994 energy efficiency centres were created in six countries with economies in transition to help government and private entities adjust to paying higher energy prices that came along with the shift to a market-based economy.¹² The centres promote energy-efficient products, techniques

12 This case draws from: Advanced International Studies Unit (AISU), 1999. *Energy Efficiency Centres in Six Countries: A Review*. Washington, D.C. (US): Pacific Northwest National Laboratory.

and services. They have helped stimulate investment in energy-efficiency projects that have saved 20 times the start-up cost of the centres themselves. The centres are staffed by economists, engineers and energy specialists. They are:

- Polish Foundation for Energy Efficiency (FEWE).
- Czech Republic Centre for Energy Efficiency (SEVEN).
- Russian Centre for Energy Efficiency (CENEf).
- Bulgarian Centre for Energy Efficiency (EnEffect).
- Beijing Energy Efficiency Centre (BECon).
- Ukraine Agency for Rational Energy Use and Ecology (ARENA-ECO).

The centres have promoted energy-efficient technologies and practices through policy reform efforts, private sector assistance, demonstration projects, training programmes and public education. The centres' approach is summarised in Table 1. Start-up funding has run out, but the centres have become financially self-sufficient by working for multilateral lending institutions, energy and environmental agencies and national and local governments.¹³

13 Advanced International Studies Unit (AISU), 1999. *Energy Efficiency Centres in Six Countries: A Review*. Washington, D.C. (US): Pacific Northwest National Laboratory.

Table 1:
Energy Efficiency Centres
Objectives and Corresponding Mechanisms for Providing Assistance¹⁴

Energy Efficiency Assistance Objectives	Programme Assistance Mechanisms
Support the transition of planned economies to democracy and market systems.	Provide assistance in policy reform and market mechanisms, joint venture development, demonstration projects and public information.
Assist industry in expanding business opportunities for energy efficiency and renewable-energy technologies and services.	Help foreign companies develop ventures with local firms by conducting market assessments for given technologies and offering assistance in doing business in the region.
Enhance economic recovery in the region by cutting energy-related capital and operating costs.	Assist local governments in meeting energy and social needs through policy reform and technical project development.
Promote East-West co-operation in science and technology, share experiences and gain a better understanding of the wealth of scientific expertise in these countries.	Create information networks and databases on energy-efficiency technologies, services and potential projects and partners.
Reduce the regional and global human and environmental health risks from energy-related air and water pollution.	Implement practical measures that reduce the negative environmental effects of energy production and use, while simultaneously promoting economic growth.

¹⁴ *Ibid.*

POLICY REFORM

Collaboration between staff at the centres and international experts has yielded a substantial body of research. Many energy sector reforms are influenced by centre reports on barriers to energy efficiency, appropriate cost-effective technologies and results from technical demonstrations.¹⁵

The centres have helped local and national governments set policies that encourage energy efficiency. Energy pricing, privatisation, financing, and the development of codes and standards are the main objectives of the centres' policy-reform efforts. All the centres have had a role in shaping energy-efficiency policy in their countries. The US President's Committee of Advisors on Science and Technology was so impressed by the Centres' efforts that it stated in a 1999 report " [t] hese centres... have been instrumental in influencing energy and environmental policies favourable to clean energy technologies, preparation and financing of major projects, and market-transformation activities".¹⁶

Some outstanding policy-reform efforts include:

- The Polish Energy Efficiency Centre (FEWE) drafted demand-side management legislation that was the first of its kind in Eastern Europe;
- The Czech Republic Energy Efficiency Centre (SEVEN) drafted the standards and labelling provisions of the Czech energy law and led the development of the Czech Republic's national action plan on climate change;
- The Russian Centre (CENef) drafted the first version of the current Russian Federal Law on Energy Conservation and helped implement local energy-efficiency laws and codes in more than fourteen regions of the Russian Federation;
- The Bulgarian Centre (EnEffect) helped develop the nation's first energy-efficiency standards for household appliances and assisted municipalities develop local energy-efficiency plans;
- The Beijing Energy Efficiency Centre (BECon) helped develop and implement China's Energy Conservation Law. It also was influential in

15 Documents can be found at: <http://www.pnl.gov/aisu/pubs/index.htm>.

16 *Powerful Partnerships: The Federal Role in International Co-operation on Energy Innovation*, President's Committee of Advisors on Science and Technology, USA, September 1999.

the design of the “Tenth Five-Year Plan on Energy Conservation”, the first plan to be based on market mechanisms;

- The Ukraine Agency for Rational Energy Use and Ecology (ARENA-ECO) supported the development of Ukraine’s Comprehensive State Energy Conservation Programme.

PRIVATE SECTOR ASSISTANCE

The centres have implemented a range of locally-driven projects aimed at supporting business endeavours that led to energy savings. They have worked with more than 250 companies to promote business opportunities which produce energy-efficient equipment, such as basic controls, thermostats, energy-efficient windows, steam traps, lighting and a broad range of other technologies.

For example:

- SEVEN helped establish the first energy service company (ESCO) in the Czech Republic. The company has generated tax revenues worth twice the initial investment in all six centres;
- ARENA-ECO helped Honeywell, Inc. develop efficiency projects at the Kharkiv Municipal Heating Company and the Zhidachiv pulp and paper plant in the Ukraine;
- BECon helped establish the US-Chinese joint venture Kangsen-Armstrong Company, Ltd., which produces high-efficiency steam traps in China;
- CENEf located a Russian partner for a US firm that distributes equipment for mitigating sulphur-dioxide emissions from factories.

DEMONSTRATION PROJECTS AND TRAINING

The centres have taken a lead role in demonstration projects to build confidence in energy-efficient technologies. Local engineers and plant managers are adopting energy-management techniques based on the demonstrations and related training.

- FEWE led the first demonstration project for Poland’s Krakow district heating system;

- SEVEN led a district heating demonstration in the Czech city of Plzen;
- CENef is involved in the World Bank's "Enterprise Housing Divestiture Project," which is upgrading the efficiency of some Russian households, valued at \$300 million;
- EnEffect helped lead demonstration projects in regional hospitals in the Bulgarian cities of Gabrovo and Stara Zagora;
- BECon has implemented six demonstrations of energy-efficient lighting in hotels, shopping centres and farms;
- ARENA-ECO has made recommendations to Gostomel glass plant, Avdeevka coke chemical plant, and Rosich food plant on energy-efficiency upgrades.

PUBLIC INFORMATION

The centres' radio and television campaigns have helped raise public awareness of energy-efficiency options. They have also spread energy-efficiency information through newsletters that target the private sector, and through their web sites.¹⁷

For example:

- FEWE recently developed an educational brochure on energy and environment for local schools and a television series on simple ways to save energy. It was broadcast on Poland's most popular daytime programme;
- SEVEN presents an annual award to the best graduate dissertation on efficiency. It has also designed a computer programme on energy efficiency for use in secondary schools;
- CENef publishes *Energy Efficiency*, a journal on current related issues in Russia.

¹⁷ Links to these websites can be found at: <http://www.pnl.gov/aisu/centres.htm>.

FUTURE OUTLOOK

The centre directors plan to build on their successes in the coming years, expanding regional and local efforts. Several centres aim to include renewable-energy projects in their activities. They hope to see the creation of new centres in other transition countries and in the developing world.

LESSONS LEARNED

In-country capacity building has been an effective driver for policy reform in countries with economies in transition.

- Investors require information and expertise when considering business opportunities. The centres have met this need by providing market analyses, energy data and overviews of business opportunities.
- Capacity-building efforts to support energy efficiency must be multi-faceted if they are to succeed. Experience gained through technical demonstrations benefits both legislative and regulatory efforts and business investment.

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St. Basil, Basilica, Red Square in Moscow

© UNESCO, Alexis Varonoff

Case Study

Spreading the Word: Dissemination of Photovoltaic Systems in Kenya

Project Characteristics

Location:	Kenya
Contract type:	Private business initiative
Financing:	Generally homeowner investment in equipment; donor financing for information dissemination
Type:	Photovoltaic technology diffusion in rural areas
Developer:	Originally a private company; now a self-sustaining market

INTRODUCTION

The use of photovoltaic (PV) systems in Kenya began in 1984 when Harold Burris, an American engineer, founded Solar Shamba.¹⁸ This small company focused on meeting the energy needs of households and schools in rural Kenya. This strategy differed from that of the large, infrastructure-oriented, international aid programmes at the time. Burris developed a training programme for young, unemployed Kenyans who installed PV systems in local secondary schools.

These systems attracted considerable attention from nearby communities, and Solar Shamba began to supply PV systems to power household lights, radios and televisions. Their popularity with homeowners blossomed. Cumulative sales soared to more than 100,000 units. Current sales are about 20,000 systems each year. More than 40 manufacturers, vendors, installers and service providers supply this demand. The market developed without substantial subsidies and with only minimal outside support.

Kenya has become the hub of an active and internationally recognised

18 This case was developed from: Jacobson, A., R. D. Duke, D.M. Kammen, M. Hankins (2000). "Field Performance Measurements of Amorphous Silicon Photovoltaic Modules in Kenya", *Conference Proceedings of the American Solar Energy Society (ASES) – June 16-21, 2000*. Madison, WI (US): American Solar Energy Society; and Acker, R. and D.M. Kammen, 1996. "The Quiet (Energy) Revolution: the Diffusion of Photovoltaic Power Systems in Kenya". *Energy Policy*, 24: 81-111.

regional market for PV systems. A recent wave of grants and development assistance programmes have been initiated to diffuse PV systems in East Africa.

THE ROLE OF INFORMATION DISSEMINATION

The PV market in Kenya grew as a result of both formal and informal information dissemination. Development agencies, private and volunteer organisations such as USAID, GTZ and the Care and Bellerive foundations helped commercialise the PV systems and later in publicising them.

Word-of-mouth Communication is Powerful

Word-of-mouth communication played the main role in bringing PV technology to Kenyan households. In a survey of owners, 75% reported that they first learned about photovoltaics from friends and neighbours, often having seen one in action. Ownership of a PV system can earn a household a local reputation: neighbours see the lights at night and friends are invited over to watch television. Owning a PV system can be a status symbol.

The rural poor are typically unwilling to risk significant investments that have unproven benefits. A potential buyer wants to see a system first-hand or hear an evaluation from a trusted friend.

Through grassroots spreading of information, the PV market in Kenya has generated its own technical and social momentum. Retailers in Nairobi report that they no longer need to advertise as much as they once did, because knowledge of photovoltaics is now well known. Though they continue some promotional efforts such as demonstrating their products at agricultural shows, these companies receive so many customer inquiries, that there is not much need for advertising.

Many Kenyans turned to PV systems because expansion of the national electricity grid has been slow. PV systems tend to be the least costly electricity supply when homes are located far from existing grids. Interestingly, many households choose PV even when they are located near a grid. PV systems are seen as offering freedom from blackouts and fluctuations in energy prices. Some Kenyans regard PV as the least-costly technology, though in fact

PV can be twice as expensive as diesel generators. High prices largely due to heavy taxes and import duties on PV equipment.

... But There is a Catch

While word-of-mouth helped to spread PV technology relatively quickly, it has drawbacks. It can be inaccurate. Gaps in reliable information can adversely affect system operation and maintenance, and have led consumers to buy inferior systems. Owners are often unfamiliar with how to best use their system. Small systems are frequently overloaded and not positioned at the best angle to the sun.

In addition, purchasers are often unable to distinguish between brands of varying quality. In a survey of PV owners only a few could differentiate between products, in terms of their reliability and life-time. As quality varies dramatically among the modules, consumers' inability to identify high quality can impose a major cost. One brand has one-third of the market even though it consistently performs below its rated output. Because of system malfunctions, thousands of rural Kenyan households have lost most or all of their investment in what is often the most expensive durable good they own. This could slow down continued development of the PV market as word spreads of system malfunctions.

Responses to this concern have been to establish standards and labels, such as those of the International Electrotechnical Commission (IEC). The PV Global Approval Programme (PVGAP) is working to develop "recommended standards" in cases where the IEC has yet to act, as well as a PVGAP quality "mark" for PV components, and a quality "seal" for whole systems. It is unclear, however, how quickly the manufacturers who sell into the Kenyan market will seek or receive certification. Moreover, in the absence of consumer education, a "seal of approval" of this sort may have little impact on the Kenyan market.

LESSONS LEARNED

- Information conveyed by word-of-mouth and by seeing a system working at a neighbour's home can be very influential in stimulating demand for technologies that provide basic services.
- Formal channels of information dissemination are often needed in support of informal ones.

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Case Study

Effective Teamwork: Technology Co-operation in the Philippines

Project Characteristics

Type:	Technology-needs assessment and market identification for renewable energy
Location:	Philippines
Financing:	Philippine and US governments
Developer:	US Technology Co-operation Assessment Pilot Project

INTRODUCTION



Small waterfall in the Philippines.

© NREL

The Technology Co-operation Assessment Pilot Project (TCAPP), a US bilateral initiative, fosters the implementation of climate-friendly technologies in partner developing countries.¹⁹ TCAPP operates on the premise that technology transfer must be driven by host-country needs, harness the power of the private sector and involve collaboration at many different levels. TCAPP programmes are administered through the US National Renewable Energy Laboratory. Partner countries are Brazil, China, Egypt, Kazakhstan, Mexico, the Republic of Korea, the South African Development Community and the Philippines.

Since its inception in November 1997, TCAPP-Philippines has identified priority technologies, suggested policy reforms, assisted in organising and

¹⁹ This case draws from: Del Callar, C.C. and F.A. Benito, "TCAPP Programme in the Philippines", presented at the 2nd CTI Industry Joint Seminar on Technology Diffusion in Asia. Cebu, Philippines, January 2000.

disseminating information on renewable-energy resources and provided technical assistance for project development.

TECHNOLOGY PRIORITIES

The Philippines, a nation with more than 7,000 mountainous islands, is well-endowed with sun, wind and moving water as potential energy sources. Nevertheless, almost half of all Filipinos lack electricity.

To help bring clean-electricity to the country, TCAPP assembled a team to make recommendations. The diverse team of Philippine governmental agencies, citizens groups and private-sector companies, along with international agencies and companies, selected renewable energy technology deployment as TCAPP-Philippines' primary objective. Photovoltaics and wind energy were designated as primary technologies. The President's Office and the Philippine Department of Energy (P-DOE) urged TCAPP to focus on increasing the use of renewable energy in rural areas to alleviate poverty. Energy-efficiency initiatives were identified as a secondary goal.

Technologies were chosen on the basis that they would increase the local capacity for renewable-energy technology, be commercially viable and contribute to social and economic development. TCAPP is expected to help the Philippines meet its obligations under the UNFCCC process, electrify rural communities and help reduce its reliance on energy imports.

POLICY ON THE "FAST TRACK" TO SUCCESS

One of the TCAPP team's first actions was to suggest "fast track" policy reforms to facilitate the deployment of renewable energy. In March 2000, the Secretary of Energy implemented the first part of the recommendations. The policy reforms taken include:

- Streamlining the requirement for renewable electricity generation projects to sell power to the grid;
- Establishing a case-by-case evaluation for a spinning reserve requirement²⁰

20 A spinning reserve requirement is a level of electricity generation that must be available at all times to respond to peak energy demand.

on renewable generation projects for the main grid, and clarifying that these requirements do not apply to renewable-energy generation on small grids;

- Removing the 60% thermal efficiency requirement for cogeneration facilities that use renewable energy;
- Eliminating the requirement for a power purchase agreement for renewable electricity generation projects;
- Removing the review and approval requirements for projects that supply electricity to a designated user.

PROVIDING INFORMATION TO BUILD MARKETS

Harnessing the Sun's Power for Agriculture... all over again

TCAPP-Philippines is helping to develop a pilot programme for a solar-powered water pump for agricultural use. It has gathered initial data for the economic evaluation and researched the world-wide cost and performance of photovoltaic-powered pumps that can replace diesel pumps. A pilot project will be launched if the results of the study are encouraging. Preliminary estimates suggest a potential market size of 10 MW installed capacity annually.

Hydropower Market Development

The lack of available and accurate data on the Philippines' hydroelectricity market was raised by the US Hydropower Council for International Development in September 1999. As a co-operative effort to rectify this problem, TCAPP, P-DOE, and East Indies Consulting Services compiled a database on both large- and small-scale hydroelectricity, existing and proposed hydro plants and electric co-operatives and utilities. Available information includes: estimated annual net energy production, internal rate of return, construction costs and feasibility studies of potential projects. Such information can help developers make informed investment decisions. Based on current data, the Philippines has an estimated 1,784 MW of potential mini-hydro capacity.

Wind/diesel Hybrids

TCAPP-Philippines identified issues for market development and possible approaches to increase private investment in hybrid wind/diesel power generation. TCAPP contributed wind-energy expertise on technical issues related to hybrids. Estimates show a long-term potential market of 300 to 500 MW of hybrid wind/diesel or natural-gas generation for isolated grids. Currently, there is interest from one developer, but no contracts are yet in place.

RESULTS

As a direct result of the policy changes, several international firms have requested additional information about renewable-energy markets in the Philippines. The improved information about hydropower projects has attracted interest in developing projects with electric co-operatives to improve the efficiency of existing hydro facilities.

LESSONS LEARNED

The Philippines' project identified climate-friendly technologies that could thrive in its unique geographical and economic environment. It also identified barriers to their implementation and promoted practical solutions:

- Market and project identification by experts can turn up investment options that may not otherwise be obvious to project developers.
- Well-organised information can stimulate private sector-interest and increase investment.
- Policy reforms can have an immediate effect on private-sector investment.

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Village meeting on energy decisions

Case Study

Testing Solar Stoves in South Africa

Project Characteristics

Type:	Solar stove field test
Location:	Republic of South Africa
Cost:	€ 3,100,000
Financing:	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, ²¹ Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, ²² and Department for Mineral and Energy, South Africa
Developer:	Deutsche Gesellschaft für Technische Zusammenarbeit ²³

INTRODUCTION

In areas where wood is hard to find, solar energy for cooking and baking can be a convenient and environmentally-sound alternative to traditional fuels. Solar stoves are in limited use in many countries, but there is little information available on their large-scale potential.²⁴

In a typical development assistance programme, a donor government would provide funds to a non-governmental organisation (NGO), which would buy an improved cooking device and provide it at low or no cost to users. In Germany, the Gesellschaft für Technische Zusammenarbeit (GTZ) assesses technology



© GTZ

Information dissemination, fashionably.
One fan of solar-cooker stoves

21 Federal Ministry for Economic Co-operation and Development (Germany).

22 Federal Ministry for Education, Science, Research and Technology (Germany).

23 German Agency for Technical Co-operation.

24 One exception is Tibet, where more than 300,000 solar cookers are in use.

needs and does field testing for the Development Co-operation ministry (BMZ). When a technology offers promise, but it is not clear that it is suited to local conditions, GTZ helps decide if it is appropriate for widespread adoption. It has done this for solar-cooking technology in South Africa.

COOKING WITH THE SUN: PROJECT DESCRIPTION

Three cooker types were tested: boxes, concentrators and flat-plate collector cookers. The four main user groups were: institutional kitchens, charitable facilities, individuals and families. Women were the focus of the study, as they usually collect fuel wood and cook. Safety, user-friendliness and reliability were the main criteria investigated.

The project team interviewed 200 households in the dry northwestern region of South Africa. Three test areas were selected. Typical of many in the region, Onseepkans is a rural village where collected wood is the primary source of fuel. Pniel, also a small village, is eight kilometres from the nearest town, where wood and paraffin (a petroleum based wax) are used as fuel. Residents of Huhudi, an electrified urban township, use mostly paraffin for cooking.

Solar cookers were tested by sixty-six families and fourteen institutions in the three test areas for one year. Thirty families served as a control group. GTZ provided three models for large families and another three models for smaller users. Over a six-month period the families rotated use among the three different models. Three large models were also tested at institutions. Questionnaires and in-depth interviews were used to gather information about users' experiences.

RESULTS

The assessment helped GTZ estimate the potential market for solar cookers in South Africa. The surveys also uncovered important differences in thermal performance among the three models, which led GTZ to suggest design improvements.

Monitoring in the three test areas showed that families used solar cookers at least twice a week, and almost all were satisfied with the results. However, the families observed accepted solar cookers as a complement to, but not as a replacement for, conventional cooking fuels.

Four solar cooker models are currently being produced in South Africa but require further development to be commercially viable. They are available at selected retail stores and supermarkets at prices ranging from \$30 to \$100.

LESSONS LEARNED

In the end, it proved easier to assess technology needs than to fill them. To be widely-accepted, the cookers had to be user-friendly, efficient, durable and affordable. To date, no solar cooker on the market satisfies all these requirements.

- Technical development must be defined by the needs of the user.
- Assessing if a technology is suitable to a region and its people is critical.
- Technological modifications are often necessary to conform to local conditions.

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ENGAGING THE PRIVATE SECTOR

Companies consider many factors before investing in a project in a developing country. Basic characteristics of a country, such as natural resources and GDP, as well as government policies are weighed carefully. Commercial banks, for example, set national lending limits, factoring in “country risks” that include the effectiveness of a country’s legal system, the strength of its institutions and its political and economic stability.

Governments can set policies that encourage overall investment. Policies on the repatriation of profits, taxes, monetary policy, environmental standards, labour laws and trade agreements influence investment decisions.

Governments also play a role in creating the “enabling environment” for investment.

Box 4.1

Effective Government Actions to Improve the Enabling Environment for Climate-friendly Technology Transfer

- introducing specific policies, to stimulate markets for climate technologies;
- reducing or eliminating subsidies for fossil fuels;²⁵
- including environmental costs in the overall price of energy services;
- strengthening intellectual property rights;
- raising consumer awareness of the benefits of clean technologies;
- developing product standards, instituting industry codes and certification procedures;
- fostering research in climate technologies;
- adapting technologies to suit local needs;
- assessing local technology needs;
- making markets more transparent.

25 International Energy Agency, 1999. *World Energy Outlook 1999 Insights – Looking at Energy Subsidies: Getting the Prices Right*. Paris (France): IEA/OECD.

Private companies play a pivotal role in technology transfer.²⁶ Governments and international funding agencies can undertake one-off projects and build local skills. Ultimately, however, the private sector is the main actor in the market.

Private companies transfer technology through loans, commercial sales, joint ventures, the licensing of intellectual property rights and foreign direct investment. Government incentives can stimulate private involvement in the transfer of climate technologies, particularly where a technology market is still in the process of developing. Used carefully, loans, grants, tax incentives and well-crafted, short-lived subsidies can help correct some market failures. Incentives are most effective when they act to correct market failures.

The following sections give examples of policies to engage the private sector.

DETAILS, DETAILS: “SOFT” ACTIVITIES ARE CRUCIAL

- A project sponsored by the United Nations Development Programme (UNDP) and Global Environment Facility (GEF) in Morocco is strengthening the country’s technical capabilities in the field of solar water heaters.²⁷ Government agencies and private firms are being trained to promote, evaluate and install solar hot-water systems. To promote their adoption, these systems value-added tax and duties on imported equipment, have been reduced.
- The Technology Co-operation Agreement Pilot Project (TCAPP) seeks out technologies with a potential for rapid implementation and then proposes reforms to existing regulations that inhibit such technologies’ deployment. The TCAPP in the Philippines helped reform the Mini-Hydro Law, reducing cumbersome permit and accreditation requirements for mini-hydro power development.

26 This is not the case for technologies to adapt to the effects of climate change where the market is dominated by public finance and there is little or no private sector involvement.

27 Pamphlet: *Ten Cases of Technology Transfer*, Global Environment Facility, June 2000.

LEGAL REFORMS, REGULATION, CODES AND STANDARDS

- The Energy Efficiency Centres have helped develop and promote new laws and agreements to support energy efficiency. Centres in China, the Czech Republic, Poland and Russia have helped local and national governments to draft legislation, regulations and other energy-efficiency measures and to establish environmental standards.
- Regulations introduced in Argentina to improve industrial energy efficiency encouraged a large steel maker to implement an environmental management system that reduces material and energy inputs.²⁸
- A UNDP project in the Ivory Coast and Senegal is training architects and builders to design and build more efficient buildings, using foreign know-how and technologies.²⁹ An energy-efficiency code for air-conditioned buildings is in the works. In the project's demonstration component, representative buildings undergo energy audits and are retrofitted, with an emphasis on air conditioning and lighting. The project also facilitates the implementation of building codes: affected parties are consulted and construction firms are trained to understand and apply the code.

MONEY TALKS: INCENTIVES ARE EFFECTIVE

- Energy-sector reforms in El Salvador, combined with government incentives for new power producers to enter the market, were instrumental in the construction of the bagasse-fired generation plant, at the San Francisco Sugar Mill.
- Investment tax credits and relaxed import tariffs helped stimulate the Indian market for wind power and photo-voltaic systems. Incentives were combined with large-scale demonstrations, which increased consumer confidence. The project, supported by the World Bank and GEF, helped to raise awareness among banks and investors on wind-power technology. From 1991 to 1998, the number of companies in the Indian wind-turbine industry increased from three to twenty-six and those in the PV

28 www.acindar.com.

29 Pamphlet: *Ten Cases of Technology Transfer*.

industry increased from 16 to more than 70. India has about 1,200 MW of installed wind capacity. India now exports wind turbines.

- In an effort to introduce butane stoves in Senegal as a way to curb deforestation, the government used grants and loans to subsidise the use of butane gas and waived a levy on bottles and accessories. The European Development Fund financed the regional gas programme. Electricité de France financed the training of workers. Government subsidies fell by two-thirds over three years, in line with a required development of the market.
- The Honduran “Renewables Law”, introduced in 1998, gives renewable-energy projects a price incentive and an exemption from income tax, VAT and import duties for the first five years of each project. It has helped to attract foreign investment. Encouraged by the new law, Enron Wind Development Corporation is developing an advanced 50-60 MW wind-power facility in Honduras.
- In the Poland Efficient Lighting Project, subsidies were given directly to manufacturers of compact fluorescent lamps. The producers labelled the lamps with a recommended retail price to demonstrate that the subsidy was passed on to the end-user. A scheme was used to ensure that manufacturers reduced prices by an amount greater than the subsidy.

GOVERNMENT LEADERSHIP GETS RESULTS

- Strong government leadership was a key factor in projects to phase-out ozone-depleting substances in Thailand and in Mexico, and replace them with CFC-free technologies.
- The government of the Inner Mongolian Autonomous Region used several methods to create markets, adapt foreign technologies and improve the manufacturing, distribution and servicing of household wind-power systems. China has subsidised such systems in Mongolia since the early 1980s. Initially, subsidies went directly to households and local governments. Since 1988, subsidies have gone to system manufacturers and then been passed on to consumers in lower purchase prices.

Case Study

Government Policies and Private Finance Work Together: India Renewable Resources Development Project

Project Characteristics

Type:	Renewable energy
Location:	India
Financing:	World Bank/Global Environment Facility
Developer:	World Bank/Global Environment Facility

INTRODUCTION

During the 1990s, new tax policies and changes in power regulations improved the investment climate for renewable-energy technologies in India. At the same time, the Indian government, the World Bank and the Global Environmental Facility (GEF) supported a renewable-energy development project to improve the functioning of commercial markets for wind, mini-hydro and solar PV technologies.³⁰ The project, along with assistance from Denmark and other sources helped the India Renewable Energy Development Agency (IREDA) to promote and finance private investment in renewable energy. IREDA now conducts marketing campaigns, offers business training, provides various types of credit and subsidies and offers other financial incentives.

360 MW of commercially-operated wind capacity and 65 MW of mini-hydro capacity were commissioned through public and private financing. Results for solar PV technology have been less than were hoped for. Even so, more than 2,200 solar home systems and solar lanterns have been financed



Installing solar panels as part of a new service module

30 This case draws from: Martinot, E., 2000. *Case Study: World Bank/GEF India Renewable Resources Development Project and The GEF Portfolio of Grid-Connected Renewable Energy: Emerging Experience and Lessons*. Washington, D.C. (US): Global Environment Facility.

with IREDA support. In West Bengal, the project demonstrated five solar power systems of 25 kW each, supplying electricity to about 500 families connected into village-scale grids. They are managed and maintained by co-operatives.

HELPING THE PRIVATE SECTOR CREATE A MARKET FOR RENEWABLES

A project limited to direct financing of renewable energy would have had limited impact. This project in India went considerably further, raising awareness of the viability of wind power and other renewable-energy technologies. As a result, many financial institutions began to invest in renewable-energy technologies. IREDA sponsored business meetings and training programmes that attracted more than 2,000 participants from state agencies, companies and banks. These meetings were supplemented by publications and advertisements aimed at helping small- and medium-sized companies market their renewable-energy products. IREDA also published several “best-practice” manuals on wind-energy projects and investments, offered financial consulting services and appraised projects for developers.

Because there was scepticism about the quality of some wind-turbines, IREDA worked with the Ministry of Non-conventional Energy Sources (MNES) to develop a wind-turbine certification programme. One cause of poor performance in the turbines, it was found, was improper siting. So, IREDA and MNES prepared guidelines on site planning and selection.

World Bank/GEF assistance increased IREDA’s ability to develop a sales and service infrastructure for solar PV systems. Several years into the project, it became clear that the lack of after-sales service and difficulties in getting credit were hindering development of the rural market. In 1998, the project began to test different models for providing services. In one model, a rural energy-service company leased PV systems to households for a monthly fee that included service and maintenance. The companies using this model were local, with strong ties to the community. Most already provided some type of related service. With training, this service has been extended to cover maintenance of PV systems.

INDIA IS NOW A MAJOR PLAYER IN THE RENEWABLE-ENERGY BUSINESS

Some 1,200 MW of wind-power capacity is now on-line in India, more than two-thirds of the total wind-power capacity in all developing countries. Most is privately owned. Part of the government's success in encouraging private investment in wind farms can be attributed to IREDA's efforts.³¹ By the late 1990s, dozens of domestic wind-turbine manufacturers had emerged, many of them joint ventures with foreign partners. Many of these manufacturers produced the latest high-technology turbine designs. Although most wind-turbine blades are still imported, domestic production of blades has now begun. Blades and synchronous generators are being exported to Europe. Installed wind-generation costs declined from around \$1,200/kW in 1991, to between \$815 and \$1,050/kW in 1998. Equipment certification has reduced risks for project developers. The number of Indian consultants qualified to develop wind-power projects has increased considerably.

It remains to be seen whether the market for renewable energy can survive in the absence of tax incentives that prevailed in the 1990s. Some concessions by state utilities will be important for continued private-sector investment.

The recent decline in wind-farm development in Tamil Nadu has been attributed to inadequate substations and weak distribution connections. Wind-power projects in India have been plagued by poor maintenance and repair, rotor blade failures due to manufacturing defects and control-system failures due to disregard of grounding regulations.³²

The solar PV market in India has grown considerably. The project helped increase solar PV capacity from 0.6 MW from 6,200 systems in the early 1990s to 50 MW from 675,000 systems in 2000. India now exports PV modules.

31 <http://mnes.nic.in/frame.htm?majorprog.htm>.

32 Jagadeesh, A., 2000. "Wind Energy Development in Tamil Nadu and Andhra Pradesh, India-Institutional Dynamics and Barriers." *Energy Policy*, 28: 157-168.

LESSONS LEARNED

- Partnerships that link government policies with private financing can work. A combination of tax incentives, favourable clean-electricity generation policies and acceptance of the technologies by commercial investors created the right environment for private investment in renewables.
- Funds and expertise provided by international organisations can help increase the capacity and effectiveness of a developing-country agency like IREDA.
- Government policies play an important role in technology transfer. Tax incentives helped stimulate the market. Import tariffs on equipment continue to inhibit clean-technology deployment.
- Different business models for the delivery of solar PV in rural areas need to be explored.

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Case Study

Policy Reform in El Salvador Stimulates Renewable Energy Development

Project Characteristics

Type:	Industrial co-generation with power sales to the grid
Location:	Suchitoto, El Salvador
Cost:	\$25,000 (grid-connection for industrial site) and \$7.5 million (10 MW cogeneration facility)
Financing:	Private investors and regional development banks: \$3.3 million
Developer:	Ingenio San Francisco (sugar mill)

INTRODUCTION



Biomass co-generation power station

© NREL

Restructuring El Salvador's energy sector began in the mid 1990s. The October 1996 electricity reform law opened the door to privatise electricity production, transmission and distribution. Previously, these functions had been the exclusive domain of the state-owned Comision Ejecutiva Hidroelectrica del Rio Lempa (CEL). The new law set the stage for a competitive power market.

Sugar is a vital agricultural export for El Salvador. Many of El Salvador's sugar mills produce their own electricity and process steam by burning bagasse, the waste product from sugar refining, in co-generation units. Co-generation is a proven technology and is frequently used in burning biomass and agricultural waste to produce both electricity and process heat.

THE NEW COMPETITIVE ENVIRONMENT

The reform law encourages private companies to help meet El Salvador's rapidly growing energy demand by allowing them to compete with CEL. It further opens the market by allowing foreign ownership of electricity companies. AES and Houston Industries, both US firms, Enersal of Chile, and the Venezuelan Electricidad de Caracas bought 75% of the shares in four of El Salvador's power distribution companies in 1998. This sell-off of state-owned enterprises netted \$585 million. The government is using the proceeds from privatisation to provide incentives to energy projects that have short payback periods. This strategy has attracted both foreign and domestic capital for energy projects.

THE SWEET RESULTS OF REFORM

Ingenio San Francisco (Ingenio) has a sugar refining operation located near Suchitoto. For many years the plant has burned bagasse in a co-generation unit to provide its own electricity and steam. It produced more electricity than it could use.

A project to improve the co-generation facility was implemented in 1995. It took advantage of an incentive offered by the national electric company to purchase power from new sources under one-year, renewable contracts. Ingenio made technical modifications at the mill to upgrade its interconnection equipment, in order to increase power production for sales to the grid. The initial investment was small – \$25,000 – and came from Ingenio's own coffers. Since then, the mill has sold more than 5.5 GWh, for an average annual output during the milling season (about 140 days per year) of approximately 1.5 GWh. This relatively small investment resulted in a highly successful new profit source.

BUILDING ON A SUCCESS STORY

Bolstered by the success and profitability of the co-generation facility, Ingenio decided to increase its electric generating capacity. The company embarked on a 10 MW generation project called Empresa Eléctrica del Norte (EEN), which uses 90% sugar cane and 10% fuel oil. In December 1999, Phase I

was completed, with a capacity of 5 MW. All of the power is sold to Compania de Alumbrado Electrico de San Salvador under a ten-year contract at 5.3 cents/kWh. This is significantly lower than El Salvador's recent average spot price of 8.5 to 10 cents/kWh.

FINANCING

The cost for both phases of the 10 MW project is estimated at \$7.5 million. External investment was essential. For the first 5 MW unit, Ingenio had difficulties securing investors and lenders. Financial arrangements took about a year to put in place. The banks required a corporate guarantee from stockholders and designation of the land at the project site as collateral. Banco Multisectorial de Inversiones and the Banco Centroamericano de Integración Económica provided debt financing, but they were unwilling to lend more than 50% of the total project cost. The loan is for the relatively short term of six and a half years, and at a commercial interest rate. Stockholders provided some equipment for the project, thereby benefiting from local tax incentives to increase imports of capital goods to expand energy production. There were other investors.

GROWING PAINS

The project is facing difficulties due to a financial crisis in the sugar industry, which has resulted in a decline in sugarcane production and a drastic reduction in the supply of bagasse to the power plant. Ingenio is looking for alternative fuel sources, such as sugarcane trash, bagasse from other sugar mills, coconut shells and other residues from agricultural plantations. Ingenio is also studying the feasibility of transporting bulky bio-fuels to the plant. If the supply problem is overcome, Ingenio intends to implement Phase II of the project to increase the installed capacity of the plant to 10 MW.

LESSONS LEARNED

- Reforms in the El Salvador electricity sector attracted investors. Deregulation has made it possible for the government to provide some

incentives for power generation that can be brought on-line quickly to meet pressing demand. Both international and domestic investments have followed.

- As the El Salvador electric sector becomes more competitive, renewables are facing tough competition from traditional generation technologies. The primary factor is cost. Renewable technologies, though much cheaper than in the past, generally remain more costly than natural gas and diesel-fired generation. Renewables also take more time to bring on-line. This puts them at a disadvantage compared to conventional equipment, which is often available in packaged units that can be installed rapidly. Part of the longer lead-time for renewables arises because arranging the financing is time-consuming. For some technologies, such as co-generation, the engineering requirements may also be more complicated.

KEY MESSAGES

- Competitive energy markets can encourage renewable-energy development. But renewables may not do well in competitive markets where environmental benefits are not given adequate consideration.
- Measures to reduce the advantages of fossil-fuel technologies over renewables may include: portfolio requirements for distribution companies; tighter emissions controls for fossil-fuel generation; or any other measure that establishes an economic value for environmental benefits.
- Power generation based on an agricultural commodity with wide cyclical price fluctuations, such as sugar cane, is more secure if contracts for diversified and technically compatible fuel sources are put in place.

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Case Study

Leverage the Market: The Prodeem Programme in Brazil

Project Characteristics

Type:	Renewable-energy technology diffusion for off-grid communities
Location:	Rural communities throughout Brazil
Contract Type:	A variety of business models
Cost:	\$10 billion
Financing:	Brazilian federal and state governments (\$10 million per year); International co-operation (\$1 million per year); Private sector investment and financing (the bulk of the funds)
Developer:	Brazilian federal and state governments; Public and private partnerships

INTRODUCTION

Children watching television powered by renewable energy



© SE27 International, Ltd., Sergio Trindade

Rural electrification is an important component of Brazil's development plan. Twenty million Brazilians live in rural areas that are not connected to the electricity grid. To meet the energy services demand of off-grid communities, Brazil's Ministry of Mines and Energy undertook the Programa de Desenvolvimento Energético de Estados e Municípios (Prodeem).

INITIAL APPROACH

When it was launched in December 1994, Prodeem was a typical public-sector social assistance programme. It aimed to supply electricity to rural communities using renewable-energy sources such as photovoltaic panels, mini-hydro turbines, wind turbines and biomass fuels. Government agents bought the equipment, transported it to remote communities, installed and demonstrated the technology. It was largely a project-orientated “give-away” programme.

A CHANGE IN COURSE

This approach proved inadequate to meet Prodeem’s objective. The enormous human resources and the vast amount of capital, estimated at \$25 billion, needed to bring electricity to all of Brazil’s rural off-grid population, was more than the public-sector alone could provide. Economic and currency crises during the 1990s further restricted public resources.

Having realised that Prodeem lacked market orientation, the government changed its approach to a decentralised market-based strategy. Delivery mechanisms are now in the hands of local entities, while Prodeem acts as a co-ordinator of markets to facilitate private investment. This shift enables Prodeem to focus its financial resources on projects in the poorest communities and to strengthen its institutional capacities. Prodeem also supports training to develop skills.

RURAL ENERGY MARKETS

Energy supply in rural areas in Brazil comes from a combination of commercial and non-commercial sources: diesel, kerosene, LPG, firewood, occasionally wind and small hydro.

The size of Brazil’s market for off-grid electricity is huge. The immense number of potential customers provides an attractive business opportunity.

Rural consumers in Brazil have limited buying power, but they do spend money to purchase kerosene, LPG and batteries. The key to success is to aggregate the demand of these communities up to a size that will attract

suppliers and to engineer the financing to match the consumers' buying power. During the transition from public assistance to a more market-based approach, government funds are used to pay for part of the equipment for energy in schools and community centres, and for community water pumping. Gradually, government funding will go to the "softer" programme elements: information, communication, market studies, R&D, consumer-demand surveys and training. The energy services will add value to the local economies, raise per capita income and improve living standards.

MARKET MANAGEMENT ORGANISATION

Prodeem makes managers responsible for developing plans and delegating tasks in their region. This involves collecting and sharing information about demand, renewable-energy sources and financing. Regional market managers pull together enough residential, community and commercial demand to form an attractive energy market. They train local entrepreneurs and form links with renewable-energy service providers. These efforts at market identification and consolidation attract investors.

Prodeem mobilises local people and businesses to carry out many "on-the-ground" activities. This frees up resources and allows Prodeem to identify communities that have been overlooked by the private sector, usually located in the poorest or most remote regions. Incentive packages are tailored to make electrification projects in these communities attractive business opportunities. Prodeem forms partnerships with local businesses, NGOs, utilities, energy-equipment manufacturers, banks, universities and vocational schools.

Starting in 2005, it is planned that all activities are to be carried out by market agents. The role of the government will be limited to setting policy, administrative co-ordination and market analysis.

ACCOMPLISHMENTS

- From 1994 to 2000, Prodeem provided more than 400,000 Brazilians with access to electricity.
- Early feedback about the market-management approach has been positive.

- International financial institutions, bilateral and multilateral development organisations and major private companies have collaborated with Prodeem and expressed interest in continuing their involvement.

LESSONS LEARNED

- Large-scale programmes to diffuse environmentally-friendly technology work best when they are market driven.
- Shifting focus from capital investment to knowledge investment as the market for a technology matures yields the most effective use of development resources.

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Case Study

Favourable Framework Attracts Large-Scale Green Investment: Harnessing the Wind in Honduras

Project Characteristics

Type:	Planned 50 to 60 MW wind farm
Location:	Cerro de Hula and the Azacualpa and Isopo Mountains, Department of Francisco Morazán, Honduras
Contract Type:	Long-term power purchase agreement
Cost:	Approximately \$70 million
Emissions Reduction:	140,000 tonnes of CO ₂ per year
Developer:	Enron Wind Development Corp.

INTRODUCTION

Enron “Wild” 1.5 MW
wind-turbine



© Enron Wind Development Corp.

The Honduran Government gives financial incentives for renewable-energy developments, with an eye to benefit both the environment and the domestic economy. These incentives helped create a more level playing field for renewable-energy production. Although problems still remain, the incentives have helped to create a favourable climate for renewable-energy investments in Honduras.

With the help of a local developer, Honduras Power Partners, Enron Wind has selected Honduras as the site for a technologically advanced wind project. In the absence of government incentives this project would not have been attractive.

SETTING THE FRAMEWORK: THE ROLE OF GOVERNMENT

The Honduran “renewables law”, enacted in 1998, provides incentives for renewable-energy projects, including guaranteed pricing. It sets a price of 10% over the marginal cost per kWh for electricity generated from renewable resources. The law also provides an exemption from income tax, value-added tax and import duties for the first five years of a renewable-energy project.

For the Enron wind project, the government’s support mitigates risk and guarantees power sales. The weak national economy, limited foreign investment in the country and the fact that this will be the first grid-connected wind project in Honduras are risk factors that the law has helped to overcome.

DEVELOPING A WIND FARM IN HONDURAS

Technology and Training

The project site is located close to the capital, Tegucigalpa. Forty Enron “Wild” 1.5 MW series wind generators with 70.5-metre diameter rotors will be mounted on 65-metre-high towers. The electrical equipment includes a step-up transformer at each turbine, four overhead collection lines and a 60 MW substation at the project’s load centre. There will also be a transformer to increase the voltage for interconnection with the transmission lines of the government-owned electricity utility Empresa Nacional de Energía Eléctrica (ENEE).

Enron will use Honduran construction companies to do the work. After commissioning, a new operation and maintenance company will provide additional local jobs. The project will train locals in the operation of the technology.

Status

Enron Wind has completed more than five years of wind monitoring and feasibility analyses. It is now working on the final project arrangements with

ENEE. Obtaining the necessary permits for a large wind facility is often difficult, but Enron Wind has obtained long-term land leases with municipalities and private landowners. The Ministry of Natural Resources and the Environment has provided the necessary clearances and the final environmental and construction permits are expected to be granted once the power purchase agreement and operational contract are signed.

Financing

Project financing is not yet complete. It will probably be a combination of equity and debt, partially guaranteed by export credit agency. Some outside equity investors have expressed interest.

Enron has submitted the wind project to the World Bank's Prototype Carbon Fund (PCF) in hopes of receiving funding in exchange for CO₂ emission-reduction credits. Under the Clean Development Mechanism (CDM) of the Kyoto Protocol, projects in developing countries may be eligible for credits if they use climate-friendly technologies in place of fossil fuels. These credits may become available for sale on an international market. The PCF is investing in pilot projects to lay the groundwork for financing through the CDM, although the rules for this mechanism are still being negotiated in the UNFCCC process.

ANTICIPATED RESULTS

The completed wind farm will add 50 to 60 MW of capacity to the Honduran grid, an expansion of about 8.5%. If the country's growing energy demand were to be met by additional thermal plants, some 345,000 barrels of oil would have to be imported and burned each year, releasing 140,000 tonnes of CO₂.

LESSONS LEARNED

- An appropriate regulatory framework and laws are needed to facilitate clean technology project development.
- Government incentives are very effective in helping climate-friendly technology compete with conventional energy sources.

- Even renewable-energy developments with fairly mature technologies, such as wind turbines, can take a long time to get underway.
- In complex infrastructure projects, project developers should work closely with government and utility officials at all stages.

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IMPROVING INTERNATIONAL CO-ORDINATION AND DEVELOPMENT AID

MORE EFFECTIVE USE OF DEVELOPMENT ASSISTANCE

Industrialised countries provide development assistance for two main reasons, to help poor countries raise their living standards and to promote their own national interests. Official development assistance is the way industrialised countries transfer know-how, capital and technology to developing countries. Development assistance includes technical assistance and concessional loans from bi- and multilateral agencies.³³

Official assistance fell by one-third in real terms during the 1990s, reflecting the lessening of Cold War tensions, frustrations with corruption and the inefficient use of aid funds and a sharp increase in foreign direct investment.³⁴ Most OECD countries spend less than 0.5% of their GNP on foreign aid.

With growing economic problems in many developing countries and reduced aid budgets, development aid must be used more effectively if it is to have any impact at all. A shift in aid strategies is taking place. It is moving away from individual projects and toward strategies that strengthen institutions and build markets. Direct aid in the technology-transfer process is now focussed on engaging, stimulating and leveraging the private sector and helping governments put in place the right enabling conditions.

Effective use of development assistance for transferring environmentally-sound technology is achieved where:

- aid is targeted to countries with strong policies and institutions that can use it efficiently and transparently;³⁵

33 Organisation for Economic Co-operation and Development, 2001. *The DAC Journal Development Co-operation 2000 Report*; Volume 2, No. 1. Paris (France): OECD.

34 [Http://www.worldbank.org/research/aid](http://www.worldbank.org/research/aid).

35 World Bank, 1998. *Assessing Aid: What Works, What Doesn't, and Why*. Washington, D.C. (US): World Bank.

- there has been extensive consultation and co-ordination among all parties on project design and implementation.

Some aid that has not met the above criteria has actually worked *counter* to development and environment goals. Aid for energy projects is mainly for fossil fuels, providing them an implicit subsidy. In some cases, aid for renewable-energy projects has been the needed catalyst to get projects off the ground. At the same time, however, it has made both the industry and consumers dependent on subsidies, thereby stifling market growth.

FACTORING CLIMATE-CHANGE CONCERNS INTO DEVELOPMENT ASSISTANCE

Efforts are underway to gain a better understanding of how development assistance affects climate-change strategies.³⁶ At present, only a very small amount of ODA is allocated for climate-friendly projects.

- Japan's "Green Aid" programme is one initiative that directs development money towards climate-friendly activities. It focuses on capacity building, information dissemination and helping countries factor environment considerations into their economic-development plans.
- In a project in the Ukraine, supported by the American and Swiss bilateral aid agencies, Ukrainian energy legislation turned out to be a key barrier to improving energy efficiency. The agencies worked with local officials to write new laws to prepare the country for more energy-efficient technology and practices.

Many governments now see their main role in the transfer of technology as facilitating the role of the private sector.³⁷ In the poorest countries, where aid supplies a large percentage of GDP and where there is practically no private investment, traditional project-based approaches to development assistance continue.

36 Organisation for Economic Co-operation and Development, 1999. *Compendium of Good Practices for Operationalising Environmentally Sustainable Development in Development Co-operation*. Paris (France): OECD.

37 IPCC, 2000a. "Methodological and Technological Issues in Technology Transfer".

IMPROVING INTERNATIONAL CO-ORDINATION

Regional and international co-operation among governments, intergovernmental organisations and private companies provides many benefits. Co-operation builds up resources and expertise, creates economies of scale, lowers transaction costs and improves the flow of information.

Developed and developing countries could accelerate technology transfer through improved co-operation. They could build larger global markets in climate technologies and improve the co-ordination of development assistance among donor countries.

- Strong partnerships among the Indian, Swiss and German governments and their refrigeration industries were a critical component of the success of the Indian Ecofrig project.
- In the Chai Meng Rice Husk Cogeneration Project in Thailand, international co-operation through the European Commission-ASEAN COGEN Programme helped overcome a lack of information on new biomass energy technologies in the region.

Research, development and demonstration can be greatly improved by international co-operation. Project demonstrations are expensive. A well co-ordinated regional effort can avoid duplication and publicise the experiences of the most effective projects.

- Regional co-operation pools resources and knowledge. The Caribbean Planning for Adaptation to Climate Change, enhanced the ability of small island cope with the effects of global warming. Rising sea levels and more frequent and severe storms are a particular worry to small island countries. The regional approach enabled participating Caribbean countries to strengthen national and regional institutions in ways that would not have been possible bi-laterally.³⁸
- The International Energy Agency co-ordinates a series of Implementing Agreements to promote low-cost international collaboration in energy technologies. This technique allows both IEA Members and non-members to pool resources for research and development projects and share the benefits. The arrangement has yielded a substantial body of research, which has been widely disseminated.³⁹

³⁸ [Http://www.cpacc.org](http://www.cpacc.org).

³⁹ International Energy Agency, 1999. *International Collaboration in Energy Technology: A Sampling of Success Stories*. Paris (France): IEA/OECD.

Case Study

Affordable Efficiency: Demand-Side Management in the Ukraine

Project Characteristics

Type:	Energy-efficiency improvements in
Location:	Kiev, Ukraine
Cost:	\$103,000 (residential buildings, pilot phase) \$118,000 (public buildings, pilot phase)
Financing:	Swiss Agency for Development and Co-operation; US Department of Energy
Developers:	INFRAS consulting, US Battelle Pacific Northwest National Laboratory, Agency for Rational Energy Use and Ecology, Kiev, Ukraine

INTRODUCTION



Programme staff analysing data
from energy-efficiency audits

© NREL

Since 1996, a demand side management (DSM) programme in the Ukraine has successfully demonstrated low-cost energy-efficiency measures. They were put in place in residential and public buildings by ARENA-ECO, a local non-governmental organisation. Support came from the Swiss Agency for Development and Co-operation and the US Department of Energy. The projects offered high returns in emissions reductions and helped Ukrainian customers with the high and increasing cost of energy.

ENERGY PRICES GO UP AND SECURITY IS A CONCERN

An important element of the success of the pilot project was the co-operation of the Ukraine Government. Reductions in energy subsidies since the early 1990s have raised energy prices for consumers considerably. For many Ukrainians, this has been a painful experience. Energy costs today account for as much as 40% of a typical Ukrainian household's expenditures. Many consumers have just quit paying their utility bills in response to price hikes. Government finances are hit hard by expenditures for energy in public facilities and by subsidies provided to poor households. Energy reform will go on and subsidies will continue to diminish. Improved energy efficiency will make reform less painful.

Ukraine depends heavily on natural gas from Russia. Out of the average annual 55 billion cubic metres (bcm) that Ukraine imports from Russia, 32 bcm is provided to the Ukraine as payment for running a transit pipeline. Depending on whose figures you believe, the Ukraine owes Russia \$1.4 billion (Ukraine figure) or \$2.3 billion (Russian figure) for the remaining 23 bcm. Russia temporarily suspended gas exports to cash-strapped Ukraine in December 2000 in response to repeated non-payment. Extrapolating from IEA estimates, the Ukraine could save the equivalent of 25 bcm of natural gas through improved energy efficiency, more than they now pay for.⁴⁰

MAKING EFFICIENCY IMPROVEMENTS

Four schools in Kiev and two co-operatively-owned buildings, each with 100 apartments, were selected for the pilot project. Energy audits determined the baseline energy consumption and estimated annual savings from conservation measures. Where no measured data were available, baseline consumption was assessed from building design data. Detailed on-site analysis was required where tenants had modified their heating systems, which was often the case. Based on the audits, a package of energy-saving measures was tailored for each building, all the measures had a payback period of less than three years. They included: district-heating with energy meters, radiator reflectors, pipe

40 International Energy Agency, 1999. *World Energy Outlook 1999 Insights – Looking at Energy Subsidies Getting the Prices Right*. Paris (France): IEA/OECD.

insulation, hot water meters for individual apartments; weatherization of windows, balancing of heating systems and repairing hot-water circulation pumps.

FINANCE

Banks in the Ukraine charge high interest rates. So donor financing was necessary.

Investments for the residential buildings were pre-financed by the Swiss Agency for Development, with a contribution from local Ukrainian authorities. The repayment contracts specify baseline energy consumption under average climate conditions with estimates of energy savings and their value at the prevailing energy price. Energy savings are split between the building owner at 25% and the project at 75%. The monthly payment has a fixed value in terms of the energy savings and a variable value in hryvnias, the Ukrainian currency. Repayments are calculated into US dollars and deducted from the client's debt, which is denominated at its initial US dollar value. This scheme provides a hedge for the lender against the devaluation of the local currency.

Investments in the public building demonstration project were financed by the US Department of Energy to test the model for a possible large-scale project involving a World Bank loan.

RESULTS

The project demonstrated the feasibility of a package of low-cost energy efficiency investments and a financing arrangement tailored to local conditions. The demonstration project showed energy savings on the order of 25% from low-cost measures alone.

In January 2000 the World Bank approved an \$18 million loan to upgrade more than 1,300 public buildings in Kiev. Total project cost is \$30 million, with \$10 million provided by the Kiev city state administration and \$2 million by the Swedish government. Measures to be installed over a five-year period are expected to reduce energy consumption by one-fourth. The measures should also reduce energy imports by about \$3.7 million annually, create fifty jobs and reduce CO₂ emissions by 65,000 tonnes per year.

The demonstration project with co-operatively-owned residential buildings also showed energy savings of 15 to 25% from low-cost measures. Savings in domestic hot-water heaters were less. In the Ukraine, the legal framework for direct interaction between government and private co-operatives is quite complex. Most co-operative managers are unfamiliar with contract law and investment planning. Education of managers and tenants helped here.

LESSONS LEARNED

- Financial mechanisms must be tailored to meet local conditions.
- Foreign aid agencies can play an important role in improving the dialogue between government and local participants.
- Small energy-efficiency demonstration projects can build investor confidence for larger efforts.
- A key barrier to improved energy efficiency in houses and public buildings can be poor government policy.
- At least for now, facilities are needed for soft financing, as well as mechanisms to encourage efficiency investments at district and municipal levels.

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Case Study

Networking is a Key Element: The EC-ASEAN COGEN Programme

Project Characteristics

Type:	Biomass co-generation
Location:	Chakkaraj, Nakorn Ratchasima, Thailand
Contract Type:	Turnkey project
Equipment Cost:	\$3,930,000
Financing:	Industrial Finance Corporation of Thailand, EC-ASEAN COGEN Programme
Developer:	Chia Meng Rice Mill
Savings:	\$994,500 (electricity, fuel oil, and rice husk disposal)
Sales:	\$300,000 (rice husk ash)
Payback Period:	Less than four years

INTRODUCTION

Chia Meng co-generation
power station



© COGEN – Asia Institute of Technology

The European Commission-ASEAN COGEN Programme brings together the industrial sectors of the South East Asian countries and European suppliers of co-generation equipment. The programme informs potential technology buyers of opportunities in co-generation and assists governments in the process of regulatory reform to promote co-generation.

COGEN helped advance the Chia Meng Rice Mill co-generation project in Thailand. Commissioned in 1997, the mill's 2.5 MW rice-husk co-generation

plant demonstrates the viability of biomass co-generation technology. Disposing of rice husks is an expensive process and an environmental problem. Burning rice husks in a co-generation plant on the rice mill site kills two birds with one stone. It solves the disposal problem, and generates electricity for use in the mill and for sale to the grid. Thailand has more than 50 large rice mills with capacity of more than 100 tons of rice per day. Chia Meng's success has led other mill owners to consider biomass co-generation.

Lack of information about rice husk co-generation technology is a barrier to its deployment. The COGEN programme links buyers and sellers of co-generation technology through a network of national teams, the COGEN secretariat and European consultants.

NETWORKING

The COGEN programme has two main components: the first is its “Business Line” and the second is support for demonstration projects. The “Business Line” gives potential investors product information and advice to help them select and procure co-generation equipment to meet their needs. It provides European suppliers with market information on the ASEAN region and guidance about various governments' investment rules and incentive programmes.

STRUTTING THEIR STUFF

The programme's second component supports full-scale co-generation demonstrations such as the Chia Meng mill. These projects demonstrate the technical reliability and economic viability of commercial co-generation. They are meant to inspire confidence in potential investors and encourage the diffusion of biomass co-generation technology. The demonstration programme provides financial and technical assistance to co-generation project developers. It also supports market studies, provides general information on co-generation technology, leads industrial tours in ASEAN and European countries and organises conferences and training. Fourteen biomass co-generation demonstration projects in South East Asia have been supported.

Results are disseminated through industry publications and by bringing visitors to see successful co-generation operations firsthand. Production manager Prapit Mananthanya expresses Chia Meng's role, *"We are proud to be part of the COGEN programme and are pleased to welcome visitors from South East Asia to show them a good example of what can be done with rice husks"*.

THE CHAI MENG PROJECT

EC-ASEAN COGEN raised awareness of rice husk co-generation in the Thai rice-milling industry, thereby laying the foundation for the Chia Meng project. It supported the full-scale demonstration project with \$325,000 for equipment and \$23,000 for training plant operators. Chia Meng's remaining costs, \$3.6 million were secured on commercial terms from the Industrial Finance Corporation of Thailand.

Norbert Classen, former general manager of the equipment supplier Bertrams-KONUS, explains that *"local rice mills would have been unwilling to take such a risk without the involvement of independent experts, such as EC-ASEAN COGEN and the Energy Conservation Centre of Thailand, who have been involved in the project right from the start."* Mr. Classen emphasised the support the programme provided in contract negotiations and in project development, *"It was important to use this bridge between the two continents."* EC-ASEAN COGEN also helped push through regulatory reform to allow small private operators to produce electricity and to lower import duties on co-generation technologies with a short payback period.

The Chia Meng biomass co-generation unit includes:

- a furnace/boiler producing 17 tonnes of superheated steam at 35 bar;
- an automatic ash-removal system;
- a 2.5 MW multi-stage fully condensing turbo-generator with condenser;
- heat exchangers using boiler flue gas to generate hot air for paddy drying.

The project has yielded annual benefits of \$994,000 in savings from fuel-oil and electricity purchases and rice-husk disposal, and \$300,000 of additional income from ash sales. The debt payback period was less than four years.

LESSONS LEARNED

- International co-operation can overcome the barrier of lack of information and stimulate the adoption of clean technologies in developing countries.
- A successful demonstration project can raise investor confidence in a technology.
- Linking technology suppliers with potential buyers can help overcome the information barrier.
- Co-generation projects often have ancillary benefits, such as eliminating the disposal of bio-residues and generating additional revenue from the sale of by-products.

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Rice field in Thailand

FINANCING CLIMATE-FRIENDLY PROJECTS

Financing climate-friendly energy projects is never easy. Traditional financing is rarely available. Some projects need grants or concessional loans with very low interest rates. In other cases, commercial financing methods can be used, but only if a new wrinkle is added that overcomes an investment barrier.

Even projects which promise an attractive return on investment often fail to find investors. All too often, investors judge a project's risks on the basis of preconceived ideas about "radical" or "futuristic" technology. They need to be educated about real risks, not imagined ones.

There are several typical barriers to financing renewable-energy and energy-efficiency projects. Most investors lack experience in these areas, so they follow overly-cautious lending policies. Domestic capital markets in most host countries are very weak. The small and medium-sized businesses involved have shaky credit ratings and risk profiles. Energy-efficient equipment generally has little value as collateral, and long-term loans are rarely granted in this area.

But the highest barrier is cost: electricity generated from renewable energy usually costs more than that generated from fossil fuels.

Nevertheless, some projects *do* get financing. In some cases, "innovative financing" has multiplied conventional project money three times over.

CONCESSIONAL FINANCE

Concessional finance generally comes from national agencies such as Denmark's Energy Agency or from multilateral institutions like the Global Environment Facility (GEF). The basic form of concessional finance is a grant, which can cover project costs directly or be used to dismantle barriers to clean-technology development and diffusion.

Because there is rarely enough assistance money to pay the full costs of projects, concessional finance is usually used to leverage private funds.

Examples:

- The Poland Efficient Lighting Project was financed by the GEF/IFC to promote compact fluorescent light bulbs (CFLs). The project provided short-term subsidies to CFL manufacturers. The manufacturers had to compete for funding, and this encouraged production of higher quality products. From 1996 to 1998 the retail price of CFLs in Poland has fallen by 30% and the number of Polish households using CFLs has almost doubled, to nearly 20%.
- The Environmentally Adapted Energy Systems project in the Baltic countries (EAES) insures against most of the risks in the projects it supports. The financial risks include currency fluctuation, volatility in fuel prices and non-payment by consumers. By taking on these risks, the EAES project improves the financial terms that participating municipalities can get from banks. It also lowers investment costs, since vendors in ordinary circumstances may inflate their prices by as much as 40% to cover the risk of non-payment.
- A project backed by the government of India, the World Bank and the GEF helped raise India's wind capacity to 1,200 MW. Small grants helped give investors experience with wind power and other renewable-energy technologies, and many financial institutions began investing in renewable-energy technologies.

COMMERCIAL FINANCE – WITH A TWIST

Energy Service Companies

An energy service company (ESCO) buys, installs and monitors energy-efficiency equipment in a client's building or factory. The ESCO is paid from the client's energy savings over a fixed period of time. The client keeps the equipment and all energy savings after its contract with the ESCO ends. The ESCO is a proven business model for implementing energy-efficiency projects. ESCOs are particularly attractive to clients with little capital or for those with a poor credit rating, because the ESCO provides the up-front investment and assumes the risk.

Most ESCO agreements take the form of a performance contract, which guarantees minimum savings in energy costs per square metre or in energy

per unit of production. The performance guarantee shifts some risk away from the client, and provides an incentive for businesses and landlords to go ahead with an efficiency project.

Export Credit Agencies

Nearly all governments in industrialised countries have an export credit agency (ECA) that provides insurance and guarantees against certain risks in order to promote exports. About 80% of export credits from the G7 countries goes to just ten developing countries.⁴¹ ECAs often finance large infrastructure projects, and their involvement in a project can attract large amounts of private capital.

Export credit agencies focus on issues like political risk and the repatriation of profits. Some ECAs provide financing in the form of loans, often subsidised or granted at a fixed rate, while others provide both loans and insurance. ECAs almost always require that the goods and services they finance come from their own country.

Export credit agencies promote exports in general, not specifically the transfer of environmentally-sound technology. Most energy-related ECA activities in developing countries still promote carbon-intensive projects. Several international campaigns are underway to introduce common environmental criteria for ECA-supported projects. If these campaigns are successful, they could yield large benefits for climate-technology transfer.⁴²

- Huaneng Power International, Inc., recently built three clean coal-fired power plants in China with assistance from the export credit agencies of the United States and the United Kingdom.⁴³

Project-Bundling Consortia

Transaction costs in infrastructure projects are generally “scale-inelastic”. Small projects can generate transaction costs as high as those of large projects. Transaction costs can represent a large percentage of the total cost for renewable-energy and energy-efficiency projects. Recently, consortia of investors have been assembled to “bundle” clean-energy projects and reduce

41 IPCC, 2000a. “Methodological and Technological Issues in Technology Transfer”.

42 See www.oecd.org and www.eca-watch.org.

43 “*Cleaner Coal Technologies – Financing*”, IEA/OECD Paris, 1999.

their transaction costs. Bundling efforts must combine *similar* projects with common tasks. Bundling can also allow for large-scale technology procurement.

- The Swedish EAES project demonstrates how bundling of projects can reduce transaction costs by up to 60%.

Case Study

Getting Subsidies Right: Poland Efficient Lighting Project

Project Characteristics

Type:	Energy efficient lamps
Location:	Poland
Cost:	\$5 million
Financing:	Global Environment Facility
Developer:	International Finance Corporation
Estimated Emissions Reduction:	529,000 tons of CO ₂ (1996-1998)

INTRODUCTION



Compact fluorescent lamps

One of the most common and controversial forms of government intervention is the subsidy.⁴⁴ Subsidies can distort markets and prolong the life of economically unsustainable products. They can reduce competition and make companies less efficient. But carefully crafted and short-lived subsidies can help remedy market failures.

In 1995, the International Finance Corporation developed a project known as the Poland Efficient Lighting Project (PELP). PELP successfully used subsidies and an information campaign to promote an energy-efficient and cost-effective product: the compact fluorescent lamp (CFL).

Before the project, a lack of information and the high initial cost of CFLs inhibited Poles from buying them. Over their lifetime, CFLs yield large electricity savings. But, Poles were reluctant to fork out a large sum

⁴⁴ This case was developed from: Granda, C.A., S. Birner, C.J. Aron and R. Woodward, 2000. *The IFC/GEF Poland Efficient Lighting Project (PELP) Final Results*. ACEEE Summer Study # 102.

for an unknown product. The PELP programme helped lower the price, raise awareness of CFLs and increase competition between manufacturers.

COMPETITIVE SUBSIDY STRATEGY

PELP avoided creating significant market distortions by having manufacturers bid for subsidies. Subsidies were given to manufacturers who bid the lowest and produced the highest quality product. Manufacturers received subsidy payments directly to avoid corruption and skimming by retailers. If a manufacturer missed its sales targets, PELP reallocated the subsidy to others.

The PELP method ensured that subsidies were actually passed along to customers in the form of lower prices. CFL manufacturers sold lamps at reduced prices and then applied to PELP for reimbursement. They submitted documents to prove that the product had been sold at the agreed-upon retail prices. The manufacturer subsidy reduced the cost paid by customers by more than the subsidy amount, since both the retail mark-up and value added tax were calculated as percentages of a lower retail price.

SUPPORTING PROGRAMMES

A public-education programme and a pilot programme in demand-side management (DSM) helped build the market for CFLs. The technology arrived in Poland in 1992 but was not well known and not sold in many stores. A consumer education campaign was conducted. As part of this campaign, PELP heavily promoted its trademark “Green Leaf” logo that indicated the CFL was high quality. The logo has become the symbol of energy efficiency and quality for lighting in Poland. Articles on PELP and energy-efficient lighting were published in newspapers and magazines. An energy-efficiency campaign was run in schools. Through such measures, CFLs have gained recognition in Poland.

The DSM pilot project targeted three cities, all had experienced electricity distribution system constraints in certain neighbourhoods. PELP and other local partners demonstrated how CFLs could reduce peak-load electricity demand. CFLs were bought in bulk directly from manufacturers and heavy

subsidies were offered to consumers. Subsidies were scaled so that residents living in areas with the largest distribution constraints received the highest subsidies. After CFLs were installed in one community, peak-load was reduced by 15%.

RESULTS

PELP created a sustainable market for CFLs in Poland and did not result in significant market distortions. By the programme's end, in 1998, the retail price of a CFL in Poland had decreased by 34% in real terms relative to 1995 prices. The PELP subsidy campaigns increased sales and heightened competition among manufacturers. The public education campaign increased consumer demand and created a lasting market. CFL penetration increased from one in ten Polish households in 1995, to one in three a year later.

The programme is estimated to have avoided 2.9 million tons of CO₂ emissions from 1996 to 2001, at a cost of about \$1.39 per tonne.

LESSONS LEARNED

- When manufacturers compete for subsidies, they produce a better product.
- Subsidies are most effective if the product is economically viable and a barrier is targeted for removal.
- Information dissemination can greatly increase the effectiveness of a subsidy.

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Case Study

Dismantling Financial Barriers: Hungary's Energy Efficiency Co-Financing Fund

Project Characteristics

Type:	Financing energy efficiency
Location:	Hungary
Cost:	\$30 million
Financing:	Global Environment Facility
Developer:	International Finance Corporation

INTRODUCTION

After more than a decade of economic and political reform, the economies of Central and Eastern Europe are still highly inefficient in their use of energy. Hungary is no exception. There is significant potential there for improvements in energy efficiency. But, savings are not being realised due, in part, to financing barriers. The economic viability of efficiency projects has improved as real energy prices in Hungary have increased towards international levels.

To encourage energy-efficiency projects, the Global Environment Facility (GEF) has given \$5 million to support the Hungary Energy Efficiency Co-Financing Fund (HEECF). The funds strengthen the capability of Hungarian banks to fund energy-efficiency projects. The project has built up a body of experience and has raised confidence in energy-efficiency investments for banks and project developers.

INCREMENTAL COSTS AND INCREMENTAL RISKS

The HEECF addresses the incremental costs and risks of energy-efficiency projects. Incremental cost is the difference in price of a project using a less expensive “dirty” technology from a project using a more expensive “clean” technology. Incremental cost analysis is an important evaluation tool used by the GEF.⁴⁵ Incremental risks are the characteristics of a project which inhibit

45 Ahuja, D., *The Incremental Cost of Climate Change Mitigation Projects*, Global Environmental Facility Working Paper, Washington, 1994.

decision-makers from undertaking a project with negative or low incremental costs, and which cannot be overcome by standard financial methods. Each risk can be assigned a potential cost and therefore incremental risks can lead to “financing gaps” in otherwise cost-effective and environmentally-beneficial projects. Technology risks (will it work?), credit risk (will the customer pay?) and sponsor risk (will the company remain solvent?), are examples of incremental risks.

The bulk of HEECF’s funds go to mitigate incremental risk. HEECF provides two mechanisms to mitigate incremental costs and risks. The fund consists of two tranches:

- To account for direct incremental costs, \$750,000 is dedicated to project preparation activities, including grants for certain administrative costs and early technical assistance;
- To address incremental risks, \$4.25 million in co-funding to leverage the resources of local financial institutions. Reducing the risk of default lowers credit risk and therefore the cost of debt financing.

The GEF reports that even projects with *negative* incremental costs are not attracting investment unless they have outside insurance against incremental risk. It is hoped that, over the long term, these interventions will change how these technologies are viewed, reduce the perceived risks and mitigate the real risks.⁴⁶

FINANCIAL STRUCTURE

The HEECF put up \$4.25 million to co-finance energy-efficiency projects in lighting, motors and industrial processes in Hungary. HEECF shares risk with the local bank that is the project leader. The credit guarantee covers up to 50% of the loan in case of default.

In fact, only about 20% to 25% of the guarantee funds were expected to be called upon. This allowed the fund to insure risk on more projects. The HEECF leveraged commercial funds at a ratio of four to one and in some cases, leveraged up to twelve to one.

46 Global Environment Facility, *Project Summary: Hungary Energy Efficiency Co-Financing Fund*, GEF, Washington, 1998.

Two Examples of Creative Financing in Action

The HEECF's \$2 million standby guarantee facility was made available to a local bank which lent to energy service companies (ESCOs) at an annual fee of one percent of the total amount guaranteed. In one case, HEECF partially guaranteed a bank's loan to a local boiler manufacturer and a contracting company acting as an ESCO to a hospital. The ESCO leased equipment to the hospital to improve energy generation and end-use efficiency. The hospital paid the lease to the ESCO from its energy savings. If the hospital were to default on its loan, the ESCO would not have been able to meet its payments. The standby facility guaranteed up to 50% of the amount outstanding on the lease. This coverage is referred to as a "subordinated recovery" or "first loss" mechanism.

In another case, HEECF provided an investment guarantee directly to an ESCO which markets and installs high-efficiency gas-fired residential heating systems for the local natural gas distribution company. The lending institution required the ESCO to maintain reserves to cover part of potential losses. The loss reserve was increased monthly to reflect any increase in exposure, especially to currency swings.

LESSONS LEARNED

- Banks in economies in transition and in developing countries may lack the ability to assume the cost and risk of energy-efficiency projects.
- Modest resources can enhance banks' capacity to finance energy-efficiency projects.

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Parliament building in Budapest

Case Study

Working Together to Lower Costs: Environmentally Adapted Energy Systems in the Baltic Sea Region

Project Characteristics

Type:	Boiler conversions, district heating renovation and renovation of buildings
Location:	Baltic Sea region
Cost:	Less than €30 million
Financing:	Swedish National Energy Administration ⁴⁷
Emissions reduction:	100,000 metric tons of carbon-equivalent per year, and reductions of sulphur dioxide and other emissions.

INTRODUCTION

In 1993, the Swedish government initiated an international programme to support energy-efficiency measures and increase the use of renewable energy. The main objective was to reduce greenhouse gas (GHG) emissions from oil- or coal-fired generation plants in the Baltic Sea region. The Environmentally Adapted Energy System (EAES) programme shows how regional co-operation between economies in transition and developed countries can facilitate technology transfer by increasing the scale of operation.

The project promised environmental benefits for Sweden and the Baltic countries. About 90% of energy systems in the Baltic countries are fossil-fuel based, particularly district heating systems. These heating systems are relatively well developed, but often in poor condition due to lack of maintenance. Many



© NREL

Energy audit of a district-heating system

⁴⁷ Formerly the Swedish National Board for Industrial and Technical Development (NUTEK).

small boilers operate at relatively low efficiency. A potentially large market for efficient combined heat and power (CHP) stations exists.⁴⁸

PROJECT DESCRIPTION

The EAES programme developed three guiding principles for boiler conversions, district heating renovation and building renovation:

- quick deployment, with standard financial and purchasing solutions;
- investment on favourable, but commercial terms;
- reliable, proven and sustainable technology.

Technical measures implemented include boiler conversions and district heating efficiency improvements. Most boiler conversions involve switching from oil or coal to biomass, generally in the form of waste-wood chips. Improvements in district heating distribution systems reduce thermal losses and improve end-use thermal efficiency in buildings.

In 1998, a € 38 million international programme for climate-related energy investment programme was adopted for a seven-year period. An additional € 7.5 million was allocated for the same period to climate-related energy R&D activities, primarily in the Baltic region.

Project example: A biomass boiler and district heating project in Lithuania

The biomass boiler and district heating project in Ignalina, Lithuania facilitated the adoption of an environmentally-sound energy system. Ignalina, located in the northeastern part of Lithuania in the Utena Region, is a city of 7,500 inhabitants. It is situated in a nature conservation area, and is subject to relatively strict environmental rules.

The annual thermal energy production before the project was 36 GWh/year from oil. Production is now 25 GWh/year from biomass fuels and 10 GWh/year from heavy oil.

48 EAES Programme Description, Statens Energimyndigheten (STEM), Stockholm. 1999.

A new wood-fired boiler was installed to cover baseload demand for heat and hot water. In 1999, stricter environmental rules were introduced that allowed only low-sulphur oil to be used for heating.

In addition to the new boiler, the project installed biomass-firing equipment, biomass fuel storage, fuel conveyors, a flue gas cleaner, civil works, buildings and control equipment. A 300 metre pre-insulated pipeline was added to interconnect the existing networks as well as 30 new substations in buildings and load centres.

Energy savings are estimated to be about one GWh/year. The replacement of some 30 GWh/year of heavy oil by biomass corresponds to a reduction of 2,300 mtC/year.

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CONCESSIONAL FINANCING

Both financing and technical assistance in the project have been assumed by the Swedish National Energy Administration (STEM). Loans are for 10 years at the Stockholm inter-bank interest rate, with a 2-year grace period. Swedish sponsors accept most of the project risks, although the loans are secured by collateral from the local municipalities. The financial risks include currency risk, fuel-price risks and the risk of non-payment by consumers.

The sponsors improve the financial terms for the participating municipalities and also lower investment costs, since vendors add up to 40% to their prices to cover the risk of non-payment.⁴⁹ The sponsors can also use competitive procurements to further reduce costs.

⁴⁹ Salay, J., *Energy Use, Efficiency Gains and Emission Abatement in Transitional Industrialised Economies: Poland and the Baltic States*, PhD dissertation, Lund Univ., Sweden, 1999.

The financial terms are highly favourable compared to true commercial terms for projects of this size, type and location. On actual commercial terms, the projects would be economically unattractive.

Given the size of the projects, transaction costs would normally be intolerable. The highly risky pre-investment development costs would discourage commercial investors. Even the 20% transaction costs achieved by the EAES programme would be too high for commercial finance. Concentrating on a few technologies has, however, successively contributed to reducing transaction costs.

RESULTS

To date, the EAES programme has sponsored some 70 projects in the Baltic countries, with a total investment of more than € 30 million.⁵⁰ In addition, about € 6 million has been spent on technical and institutional support, or about 20% of the investment costs. Total reductions in carbon emissions are estimated to be about 100,000 metric tons of carbon-equivalent per year. There have been substantial reductions of sulphur-dioxide emissions and other local pollutants.

The EAES programme reduced transaction costs for energy-efficiency improvements on both the supply and demand sides.⁵¹ The aggregation of projects saved as much as 60% in transaction costs compared to those for individual projects.⁵² These investments are heavily subsidised via concessional financing. Unlike many concessional-financing schemes in other regions, however, the EAES programme has had few loan defaults. Recent improvements in the international investment conditions for energy projects in Estonia and Latvia, where EAES has been most active, provide another indication of the programme's success.

The EAES programme has improved local skills in energy efficiency and renewable energy. For example, biomass-fired boilers are now produced commercially in the Baltic countries. Although it has fostered joint ventures between foreign and local partners, the EAES would like to see the trend to

50 *EAES Programme Description*, Statens Energimyndigheten (STEM), Stockholm. 1999.

51 Transaction costs here include all costs for consultants, administration, workshops, seminars, handbooks in local languages, etc., as well as follow-up activities such as data collection and preparation of climate reports to the UNFCCC.

52 *EAES Programme Description*, Statens Energimyndigheten (STEM), Stockholm. 1999.

local manufacturing continue on a larger scale. As indigenous skills improve, new firms can independently go ahead for investment and expertise. Foreign companies are seeking local contacts to improve their understanding of the regional markets.

STATUS

Both the climate-related energy investment and the R&D programme will continue through 2004. The undertaking is now called the Swedish International Climate Investment Programme (SICIP). It favours projects under the “flexible mechanisms” of the Kyoto Protocol.

The SICIP Programme will work with the Baltic Sea Region Energy Co-operation (BASREC). Along with the bilateral co-operation activities, BASREC is planning to test the Clean Development Mechanism in the Baltic Sea Region.⁵³

NEXT STEPS

A logical next step is to expand investments through private financing. A clearinghouse for new small-scale energy-efficiency projects is in the works. This clearinghouse involves all the countries around the Baltic Sea and is supported by the European Commission INTERREG 2C. It will build on the EAES experience to streamline the financing process, bundle similar projects and customers, reduce transaction costs and mitigate investor risk.⁵⁴ These help to overcome barriers to financing small energy projects, if they can be delivered through innovative variations on the traditional project-finance model, including performance contracting and leverage using concessional finance.

Building on the competitive procurement methods that were used in the EAES programme, such a clearinghouse can combine ESCO financing and collective procurement to reduce project costs. As in the EAES programme, an ESCO

53 BASREC membership consists of all the countries in the Baltic Sea region, including Norway and Iceland, and the European Commission. The Nordic Council of Ministers, through which this regional co-operation was originally initiated, participates as an observer.

54 T. Hammar. *Baltic Clearinghouse and Information Network – First Results*, IEA/CTI Seminar, Ostritz, Germany, December 1999.

can choose among available vendors and compete in the equipment markets to obtain lower prices. Additional income could come from sale of carbon offsets.

LESSONS LEARNED

- Bundling small projects can reduce transaction costs.
- Focussing on a few technologies can reduce transaction costs.
- Country risk can account for a high percentage of project costs.
- Using host country firms builds local skills – eventually allowing indigenous firms to undertake their own projects.
- Collective equipment purchasing lowers costs.
- Pre-investment development costs and some transaction costs are relatively scale-inelastic and their contribution to project risk is magnified.

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KEY MESSAGES

There is little doubt that anthropogenic emissions of greenhouse gases contribute to climate change. About half of these emissions come from developing countries and countries with economies in transition. Their share of emissions will continue to grow faster than those from industrialised countries. Eighty five percent of greenhouse gas emissions result from the production and use of energy, predominantly from the burning of fossil fuels.

Clean-energy technologies are commercially available today, but the developing countries and countries with economies in transition have largely failed to utilise them. There have been some instances, however, where renewable-energy and energy-efficiency technologies have been employed.

Academic theories and vague international commitments to climate-technology transfer need to be translated into action. The main findings of this book, drawn from actual case studies, provide practical guidelines for introducing clean technologies in developing countries.

Getting Players on Board

Climate-technology transfer needs to be driven by host-country needs. Bilateral and multilateral programmes can help developing countries perform many critical tasks. But the host country must have the political will to introduce clean technologies. Climate goals can be integrated into developing countries' social and economic plans and the industrialised countries' trade and aid strategies.

Donor governments, multilateral development banks and inter-governmental organisations need to find more effective ways to co-ordinate aid to developing countries. Activities such as the Climate Technology Initiative, can do just that.

Climate-related research programmes in industrialised countries must address the specific technology needs and circumstances of developing countries.

Strategic Planning

Before clean technologies can be introduced, the host country must first assess what technologies are needed. Next, it must write an implementation plan that spells out how, in what sectors and by whom the technologies will be introduced. These activities require a lot of co-ordination among various parties including government agencies, businesses, NGOs, technical experts, investors and donors.

Laying the Groundwork

Government leadership is important to technology transfer. Barriers need to be dismantled. All cases examined in this book had some degree of government involvement. Governments can demonstrate what can be done and at the same time create a market through its own purchases.

To spur private investment in clean technologies, developing countries need to establish a favourable enabling environment.

Demonstration projects can show that a new or unfamiliar technology is indeed viable. Such projects are expensive and usually require government support. Demonstration projects combine two vital ingredients of successful technology transfer. They improve information flow and build the skills and experience of those involved.

Some donor countries are now incorporating climate-related considerations into their development assistance programmes. Climate-related issues often overlap with traditional aid-related issues – especially in the energy sector. Synergies can be exploited between the two. Development assistance is shifting away from hands-on project development towards technical assistance and policy guidance.

Implementation

Networks among participants at all levels need to be strengthened. Regional networks are particularly effective. Donors have to co-ordinate their efforts. Recipients need to make use of their local resources and expertise.

Information is critical to the participation of the private sector. The lack of appropriate information is a key barrier to greater business involvement in

developing countries generally. Investors need better information on potential projects. Project developers need better information on available technologies. Donors need to talk more with industry to understand the business point of view and how they can help. International business networks should be developed that match projects with investors.

Innovative financing arrangements must be more widely employed to accelerate the deployment of clean technologies. Grants, concessional loans, financial intermediaries such as energy-service companies and accessible credit to small clean-energy producers are some of the financing devices that can be employed.

The goal of climate-technology transfer should not be merely to implement a single project – however much CO₂ it may save – but to work toward a sustainable market for climate technologies. Project efforts “ripple out” in space and time to transform markets.

Strengthening the capacity of a country’s government, its financial institutions and its labour force is the most important item on the technology-transfer agenda. It is not possible to build a market for clean-energy technologies if a country’s institutions and people cannot install and service them. Strengthened capacity decreases dependence on foreign technology suppliers. It encourages indigenous production and innovation to flourish.

Adaptation

Governments have a special role in accelerating the development and transfer of “adaptation” technologies that help vulnerable areas adapt to the adverse effects of climate change. Adaptation measures are undertaken for the good of a community, not in response to market forces. So it is a task best suited to governments.

ANNEX I

LIST OF ANNEX I COUNTRIES TO THE UNFCCC

Australia	Liechtenstein*
Austria	Lithuania ^a
Belarus ^a	Luxembourg
Belgium	Monaco*
Bulgaria ^a	Netherlands
Canada	New Zealand
Croatia*	Norway
Czech Republic ^{a*}	Poland ^a
Denmark	Portugal
European Union	Romania ^a
Estonia ^a	Russian Federation ^a
Finland	Slovakia ^{a*}
France	Slovenia ^{a*}
Germany	Spain
Greece	Sweden
Hungary ^a	Switzerland
Iceland	Turkey
Ireland	Ukraine ^a
Italy	United Kingdom of Great
Japan	Britain and Northern Ireland
Latvia ^a	United States of America

^a Countries that are undergoing the process of transition to a market economy.

* Countries added to Annex I by an amendment that entered into force on 13 August 1998, pursuant to decision 4/CP.3 adopted at COP 3.

Source: <http://www.unfccc.int/resource/conv/annex1.html>, as of 10 November 2000.

ANNEX II.

SUMMARY FOR POLICYMAKERS: METHODOLOGICAL AND TECHNOLOGICAL ISSUES IN TECHNOLOGY TRANSFER

**A Special Report of Working Group III of the Intergovernmental
Panel on Climate Change**

Based on a draft prepared by:

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INTRODUCTION

Background

Article 4.5 of the United Nations Framework Convention on Climate Change (UNFCCC) states that developed country Parties and other developed Parties included in Annex II “shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention.” The Subsidiary Body for Scientific and Technological Advice (SB STA) identified at its first session a list of areas in which it could draw upon the assistance of the IPCC. This Special Report was prepared in response to this request. It addresses the technology transfer problem in the context of all relevant UNFCCC provisions, including decisions of the Conference of Parties (COP), and Chapter 34 in Agenda 21. It attempts to respond to recent development in the UNFCCC debate on technology transfer, by providing available scientific and technical information to enable Parties to address issues and questions identified in Decision 4/CP.4 adopted by COP-4.

The Role of Technology Transfer in Addressing Climate Change

Achieving the ultimate objective of the UNFCCC, as formulated in Article 2,⁵⁵ will require technological innovation and the rapid and widespread transfer and implementation of technologies, including know-how for mitigation of greenhouse gas (GHG) emissions. Transfer of technology for adaptation to climate change is also an important element of reducing vulnerability to climate change.

This technological innovation must occur fast enough and continue over a period of time to allow greenhouse gas concentrations to stabilise and reduce vulnerability to climate change. Technology for mitigating and adapting to

55 “The ultimate objective of this Convention and any related legal instruments that the Conference of Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilisation of greenhouse gas concentrations in the atmosphere at such a level that would prevent dangerous interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner”.

climate change should be environmentally sound technology (EST) and should support sustainable development.

Sustainable development on a global scale will require radical technological and related changes in both developed and developing countries. Economic development is most rapid in developing countries, but it will not be sustainable if these countries follow the historic greenhouse gas emission trends of developed countries. Development with modern knowledge offers many opportunities to avoid past unsustainable practices and move more rapidly towards better technologies, techniques and associated institutions. The literature indicates that to achieve this, developing countries require assistance with developing human capacity (knowledge, techniques and management skills), developing appropriate institutions and networks, and with acquiring and adapting specific hardware. Technology transfer, in particular from developed countries to developing countries, must therefore operate on a broad front covering these software and hardware challenges, and ideally within a framework of helping to find new sustainable paths for economies as a whole. There is, however, no simple definition of a “sustainable development agenda” for developing countries. Sustainable development is a context driven concept and each society may define it differently, based on Agenda 21. Technologies that may be suitable in each of such contexts may differ considerably. This makes it important to ensure that transferred technologies meet local needs and priorities, thus increasing the likelihood that they will be successful, and that there is an appropriate enabling environment for promoting environmentally sound technologies (ESTs).

The Report analyses the special challenges of transferring ESTs to address climate change in the context of sustainable development. The literature provides ample evidence of the many problems in current processes of technology transfer, which makes it very unlikely to meet this challenge without additional actions for the transfer of mitigation and adaptation technologies.

What do we Mean by Technology Transfer?

The Report defines the term “technology transfer” as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental

organisations (NGOs) and research/education institutions. Therefore, the treatment of technology transfer in this Report is much broader than that in the UNFCCC or of any particular Article of that Convention. The broad and inclusive term “transfer” encompasses diffusion of technologies and technology co-operation across and within countries. It covers technology transfer processes between developed countries, developing countries and countries with economies in transition, amongst developed countries, amongst developing countries and amongst countries with economies in transition. It comprises the process of learning to understand, utilise and replicate⁵⁶ the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies.

The Report generally makes a distinction between developed and developing countries. Although economies in transition are included as developed countries under the UNFCCC, they may have characteristics in common with both developed and developing countries.

Trends of Technology Transfer

It is difficult to quantify how much climate-relevant hardware is successfully transferred annually. When software elements such as education, training and other capacity building activities are included, the task of quantification is further complicated. Financial flows, often used as proxies, allow only a limited comparison of technology transfer trends over time. The 1990s have seen broad changes in the types and magnitudes of the international financial flows that drive technology transfer.

Official Development Assistance (ODA) experienced a downward trend in the period from 1993 to 1997, both in absolute terms and as a percentage of funding for projects with significant impact on technology flows to developing countries. However, in 1998 there was an increase in ODA funding. ODA is still important for those parts of the world and sectors where private sector flows are comparatively low, like agriculture, forestry, human health and coastal zone management. Moreover, it can support the creation of enabling conditions, which may leverage larger flows of private finance into ESTs in the context of overall sustainable development goals in the recipient countries.

56 The final stage of the five basic stages of technology transfer (assessment, agreement, implementation, evaluation and adjustment, replication) as defined in the Report as a combination of actions that lead to the deployment of a given technology, once transferred, to meet a new demand elsewhere.

Levels of foreign direct investment (FDI), commercial lending, and equity investment all increased greatly in recent years. These are the dominant means by which the private sector makes technology-based investments in developing countries and economies in transition, often in the industry, energy supply and transportation sectors. However, private sector investment in the form of FDI in developing countries has favoured East and South East Asia, and Latin America.

These trends are altering the relative capacities and roles of different stakeholders. The importance of the private sector has increased substantially. However, there is a definite role for governments both in providing an enabling environment for the technology transfer process as well as participating directly in it. Many NGOs support technology transfer activities.

Stakeholders, Pathways, Stages and Barriers

Technology transfer results from actions taken by various stakeholders. Key stakeholders include developers; owners; suppliers, buyers, recipients and users of technology (such as private firms, state enterprises, and individual consumers); financiers and donors; governments; international institutions; NGOs and community groups. Some technology is transferred directly between government agencies or wholly within vertically integrated firms, but increasingly technology flows depend also on the co-ordination of multiple organisations such as networks of information service providers, business consultants and financial firms. Although stakeholders play different roles, there is a need for partnerships among stakeholders to create successful transfers. Governments can facilitate such partnerships.

There are a large number of pathways through which stakeholders can interact to transfer technologies. They vary depending on sectors, country circumstances and type of technology. Pathways may be different for “close to market” technologies and for technology innovations still in the development phase. Common pathways include government assistance programmes, direct purchases, licensing, foreign direct investment, joint ventures, co-operative research arrangements and co-production agreements, education and training, and government direct investment.

While technology transfer processes can be complex and intertwined certain stages can be identified. These may include the identification of needs,

choice of technology, assessment of conditions of transfer, agreement and implementation. Evaluation and adjustment to local conditions, and replication⁵⁷ are other important stages.

Barriers to the transfer of ESTs may arise at each stage of the process. These vary according to the specific context, for example from sector to sector, and can manifest themselves differently in developed countries, developing countries and countries with economies in transition. These barriers range from lack of information; insufficient human capabilities; political and economic barriers such as lack of capital, high transaction costs, lack of full cost pricing, and trade and policy barriers; lack of understanding of local needs; business limitations, such as risk aversion in financial institutions; and institutional limitations such as insufficient legal protection, and inadequate environmental codes and standards.⁵⁸

There is no pre-set answer to enhancing technology transfer. The identification, analysis and prioritisation of barriers should be country based. It is important to tailor action to the specific barriers, interests and influences of different stakeholders in order to develop effective policy tools.

INCREASE THE FLOW; IMPROVE THE QUALITY

Government actions can transform the conditions under which technology transfer takes place. The spread of proven ESTs that would diffuse through commercial transactions may be limited because of the barriers listed above.

The three major dimensions of making technology transfer more effective are capacity building, an enabling environment and mechanisms for technology transfer, all of which are discussed in more detail in the subsections below.

Building Capacity

Capacity building is required at all stages in the process of technology transfer. Social structures and personal values evolve with a society's physical infrastructure, institutions, and the technologies embodied within them. New technological trajectories for an economy therefore imply new social

⁵⁷ See previous page.

⁵⁸ See Technical Summary and Chapters 3, 4 and 5 of the main report.

challenges. This requires a capacity of people and organisations to continuously adapt to new circumstances and to acquire new skills. This applies both for mitigation and adaptation technologies.

Comparatively little consideration has been given in a systematic way to what capacity building is required for adaptation to climate change.

Human Capacity

Adequate human capacity is essential at every stage of every transfer process. The transfer of many ESTs demands a wide range of technical, business, management and regulatory skills. The availability of these skills locally can enhance the flow of international capital, helping to promote technology transfer.

Developed country governments, in particular, can ensure that training and capacity building programmes they sponsor consider the full range of information, financial, legal, and business consulting and engineering services that technology transfer requires, as well as the local conditions under which these may be provided. This requires co-operation with local governments, institutions and stakeholders, commercial organisations and consumers/users.

Developing country governments can build local capacities to gear them for technology transfer. Training and human resource developments have been popular development assistance activities. Future approaches can be more effective by better stressing the integration of a total package of technology transfer, focusing less exclusively on developing technical skills and more on creating improved and accessible competence in associated services, organisational know-how, and regulatory management.

Organisational Capacity

It is important to recognise the need for participatory approaches and to strengthen the networks in which diverse organisations contribute to technology transfer. In technology intensive economies, technology increasingly flows through private networks of information and assessment services, management consultants, financial firms, lawyers and accountants, and technical specialist groups. Local government agencies, consumer groups, industry associations and NGOs may ensure that technology meets local needs and demand. This organisational infrastructure can help reduce but will

not eliminate risks arising from deficiencies in legal systems. Although many actions that facilitate the growth of such networks are already underway, initiatives of particular importance to EST transfer include:

- Expansion of opportunities to develop firms for management consulting, accounting, energy service, law, investment and product rating, trade, publishing and provision for communication, access to and transfer of information, such as Internet services;
- Encouragement of industry associations, professional associations and user/consumer organisations;
- Participatory approaches to enable private actors, public agencies, NGOs and grassroots organisations to engage at all levels of environmental policy-making and project formulation;
- Where appropriate decentralisation of governmental decision-making and authority, in relation to technology transfer, to effectively meet community needs.

Information Assessment and Monitoring Capacity

Information access and assessment are essential to technology transfer. However, focusing too narrowly on information barriers while ignoring the later stages of the transfer process can be less productive. The roles of governments and private actors in technology assessment are changing. Private information networks are proliferating through specialised consulting and evaluation services and over the Internet. Increasing FDI also demonstrates that many ESTs can diffuse rapidly without direct government action. Governments in developing countries, developed countries, and countries with economies in transition may wish to consider:

- Developing improved indicators and collecting data on availability, quality and flows of ESTs to improve monitoring of implementation;
- Developing technology performance benchmarks for ESTs to indicate the potential for technological improvements;
- Improving information systems and linking them to international or regional networks, through well-defined clearing houses (such as energy efficiency and renewable energy centres), information speciality firms, trade publications, electronic media, or NGOs and community groups.

Enabling Environment and Extra Effort to Enhance Technology Transfer

Governments, through, *inter alia*, sound economic policy and regulatory frameworks, transparency and political stability can create an enabling environment for private and public sector technology transfers. Although many ESTs are in common use and could be diffused through commercial channels, their spread is hampered by risks such as those arising from weak legal protection and inadequate regulation in developed countries, developing countries and countries with economies in transition. But many technologies that can mitigate emissions or contribute to adaptation to climate change are not as yet commercially viable. Beyond an enabling environment, it will take extra efforts to develop and enhance the transfer of those potentially viable ESTs. The following actions could increase the flow of ESTs and improve its quality.

All governments may therefore wish to consider:

- Enacting measures, including well-enforced regulations, taxes, codes, standards and removal of subsidies, to internalise the externalities to capture the environmental and social costs, and assist the replication of ESTs;
- Reforming legal systems. Uncertain, slow and expensive enforcement of contracts by national courts or international arbitration and insecure property rights can discourage investment. Reforming administrative law to reduce regulatory risk and ensuring that public regulation is accessible to stakeholders and subject to independent review;
- Protecting intellectual property rights and licenses in such a way that innovation is fostered, while avoiding misapplication, which may impede diffusion of ESTs;
- Encouraging financial reforms, competitive and open national capital markets, and international capital flows that support foreign direct investment. Governments can expand financial lending for ESTs through regulation that allows the design of specialised credit instruments, capital pools, and energy service companies;
- Simplifying and making transparent programme and project approval procedures and public procurement requirements;
- Promoting competitive and open markets for ESTs;

- Stimulating national markets for ESTs to facilitate economy of scale and other cost reducing practices;
- Encouraging multinational companies to show leadership and use the same standards for environmental performance wherever they operate;
- Creating awareness about products, processes and services that use ESTs through means such as eco-labelling, product standards, industry codes, and community education;
- Using legislation, enhancing transparency, and increasing participation by civil society to reduce corruption in conformity with international conventions.

Governments of developed countries and countries with economies in transitions may wish to consider:

- Stimulating fair competition in EST markets by discouraging restrictive business practices;
- Reforming export credit, political risk insurance and other subsidies for the export of products or production processes to encourage foreign direct investment in ESTs;
- Developing environmental guidelines for export credit agencies to avoid a bias against, and promote the transfer of, ESTs, and discourage the transfer of obsolete technologies;
- Reducing the use, as trade policy measures applied to ESTs, of tied aid;
- Developing modalities and/or policies to improve the transfer of ESTs that are in the public domain;
- Increasing public funding for research and development (R&D) in cleaner technologies to reflect the high rate of social return and, wherever possible, enhancing the flows of ESTs arising from their publicly funded R&D programmes by entering into co-operation with developing countries in R&D partnerships and international research institutions;
- Increasing flows of national and multilateral assistance, including funding especially in programmes targeted to environmental technologies, including patent licensing of ESTs where appropriate. Attention should also be paid to supporting pathways for transfer of ESTs among developing countries.

Governments of developing countries may wish to consider:

- Ensuring assessment of local technology needs and social impact of

technologies so that transfer of and investment in ESTs meet local demands;

- Expanding R&D programmes, aiming at the development of ESTs particularly appropriate in developing countries and adjustment to local conditions; promoting complementary policies for ESTs;
- Improving pathways for technology transfer among developing countries through information regarding the performance of ESTs in developing countries, joint R&D, demonstration programmes, and opening markets for ESTs;
- Developing physical and communications infrastructure to support private investments in ESTs and the operations of intermediary organisations providing information services;
- Improving the identification of specific barriers, needs and steps towards introduction of ESTs by consulting with priority stakeholders;
- Continuing to improve macroeconomic stability to facilitate ESTs to be transferred.

Mechanisms for Technology Transfer

National Systems of Innovation

The literature shows that National Systems of Innovation (NSIs) which integrate the elements of capacity building, access to information and an enabling environment into comprehensive approaches to EST transfer add up to more than the individual components and support the creation of an innovation culture. Subsystems and the quality of interconnections within them can successfully influence technology transfer. The concept of NSIs can be enhanced through partnerships with international consortia. Partnerships would be system oriented, encompass all stages of the transfer process, and ensure the participation of private and public stakeholders, including business, legal, financial and other service providers from developed and developing countries.

NSI activities may include:

- Targeted capacity building, information access, and training for public and private stakeholders and support for project preparation;
- Strengthening scientific and technical educational institutions in the context of technology needs;

- Collection and assessment of specific technical, commercial, financial and legal information;
- Identification and development of solutions to technical, financial, legal, policy and other barriers to wide deployment of ESTs;
- Technology assessment, promotion of prototypes, demonstration projects and extension services through linkages between manufacturers, producers and end users;
- Innovative financial mechanisms such as public/private sector partnerships and specialised credit facilities;
- Local and regional partnerships between different stake-holders for the transfer, evaluation and adjustment to local conditions of ESTs;
- Market intermediary organisations such as Energy Service Companies.

Official Development Assistance (ODA)

Official Development Assistance (ODA) is still significant for developing countries and successful transfers of ESTs. ODA can also assist the improvement of policy frameworks and take on long-term capacity building. There is increasing recognition that ODA can best be focused on mobilising and multiplying additional financial resources.

Global Environment Facility

The Global Environment Facility (GEF), an operating entity of the UNFCCC Financial Mechanism, is a key multilateral institution for transfers of ESTs. Compared to the magnitude of the technology transfer challenge, these efforts are of modest scale, even when added to the contributions from bilateral development assistance. The GEF currently targets incremental, one-time investments in mitigation projects that test and demonstrate a variety of financing and institutional models for promoting technology diffusion, thus contributing to a host country's ability to understand, absorb and diffuse technologies. GEF also supports capacity building projects for adaptation consistent with limitations currently imposed by Convention guidance. Continued effectiveness of GEF project funding for technology transfer may depend on factors such as:

- Sustainability of market development and policy impacts achieved through GEF projects;

- Duplication of successful technology transfer models;
- Enhanced links with multilateral-bank and other financing of ESTs;
- Funding for development and licensing of ESTs;
- Co-ordination with other activities that support national systems of innovation and international technology partnerships;
- Attention to technology transfer among developing countries.

Multilateral Development Banks

Governments may use their leverage to direct the activities of Multilateral Development Banks (MDBs) through their respective Boards and Councils in order to:

- Strengthen MDB programmes to account for the environmental consequences of their lending;
- Develop programmatic approaches to lending that remove institutional barriers and create enabling environments for private technology transfers;
- Encourage MDBs to participate in NSI partnerships.

The Kyoto Protocol Mechanisms and the UNFCCC

The analysis of the literature on the Kyoto Protocol Mechanisms, based on the preliminary stage of development of the rules for these, suggests that if they are implemented, the Mechanisms may have potential to affect the transfer of ESTs.

The extent to which Article 4.5 of the UNFCCC has been implemented is being reviewed by the UNFCCC. Given this evolving process, the IPCC has not been able to assess this matter.

SECTORAL ACTIONS

The key actions for the transfer of mitigation and adaptation technologies vary across sectors. Governments, private actors and community organisations are all involved in technology transfer in each sector, although their roles and the extent of their involvement differ within and across sectors. It is important to note the special characteristics of adaptation technologies. Adaptation in anticipation of future climate change is faced with uncertainty about location,

rate and magnitude of climate change impacts. Adaptation technologies often address site-specific issues and their benefits are primarily local, which could hamper large-scale replication. On the other hand, they could reduce vulnerability not only to anticipated impacts of climate change but also to contemporary hazards associated with climate variability.

Central lessons learned through the sectoral studies are: (1) networking among stakeholders is essential for effective technology transfer; and (2) most effective technology transfers focus on products and techniques with multiple benefits. Actions that have been effective in technology transfer in the sectors evaluated in the Report are.

Buildings

World-wide, the mix of relevant ESTs will vary, depending upon the climate, rural-urban distribution, and historical context. The effective actions for the transfer of ESTs may include: (1) government financing for incentives for the construction of more energy-efficient and environmentally-friendly homes; (2) building codes and guidelines, and equipment standards developed in consultation with industry to minimise adverse impacts on manufacturers; (3) energy and environmental performance labels on consumer products; (4) government programmes for more energy efficient and environmentally-friendly buildings, office appliances and other equipment; (5) demand-side management programmes to promote energy-efficient lighting and equipment; and (6) R&D to develop products in the building sector that meet community priorities.

Transport

Technological options – improved technology design and maintenance, alternative or improved fuels, vehicle use change, and modal shifts – as well as non-technical options, transport demand reduction, and improved management systems can reduce GHG emissions significantly. There are also non-transport options such as urban planning and transport demand substitution, such as telematics and improved telecommunications. Resource availability, technical know-how, and institutional capacity are among the factors that affect the cost and transfer of these options.

Government policies can promote co-operative technology agreements

among companies of different countries, joint R&D, joint information networks, improved technical and management skills, and specialised training programmes. Adoption of appropriate standards and regulations can stimulate and facilitate technology transfer within and among countries. Partnership between government and the private sector and among countries can also help promote technology transfer within and among countries.

Industry

New processes, efficient energy and resource use, substitution of materials, changes in design and manufacture of products resulting in less material use, and increased recycling, can substantially reduce GHG emissions. Environmental legislation, regulation and voluntary agreements between government and industry can stimulate the development of efficient technologies and can lead to increased use of ESTs. Public technology assessment capabilities are important to provide information and capabilities to successfully transfer ESTs. Well-defined clearinghouses can be useful in disseminating information to improve energy efficiency, especially with respect to small- and medium-sized enterprises that often do not have the resources to assess technologies. Long-term support for capacity building is essential, stressing the need for the cooperation of equipment and software suppliers and users. Experience has shown that investment in developing local capability to undertake adjustment to indigenous conditions is crucial to the success of industrial EST transfer.

Energy Supply

In general, the private sector plays a strong role in the transfer of energy supply technologies based in oil and gas sources and technology transfer mechanisms have been established for some time. Restructuring of the electricity sector world-wide is rapidly changing the direction of investments in the power sector with growing participation of the private sector. At the same time, the transfer of energy supply technologies for some other conventional and renewable sources, which often depend on the government to preserve or increase their presence in the market, is restricted due to institutional and socio-economic barriers. Nevertheless, the role of the government and multilateral banks is important in every sector to foster and ensure conditions for international financing, establish appropriate regulatory frameworks and

create conditions to couple new energy investments, environmentally sound projects and sustainable development. Enabling actions by governments to promote energy options, including renewable resources, that are assisting to mitigate climate change, can be crucial to mobilise private capital for ESTs and raise increased attention to energy efficiency.

Agriculture

Development of appropriate information bases on, *inter alia*, improved crop species and varieties, irrigation facilities, different tillage and crop management systems, and livestock manure treatment, including biogas recovery systems, can facilitate and promote the transfer of adaptation and mitigation technologies within and across countries and integration with indigenous solutions. Governments can create incentives for the transfer of ESTs by improving national agricultural information systems to disseminate information on ESTs, and expanding credit and savings schemes to assist farmers to manage the increased variability in their environment. The existing Consultative Group on International Agricultural Research (CGIAR) system may be one possible model for an R&D network among countries to build such an information base. Capacities to deal with climate change technologies and national agricultural research systems including those that investigate carbon storage, and early warning systems, are important elements. Efforts by developed countries and multilateral agencies can be improved to enhance this R&D system.

Forestry

Government, community, and international organisations, including conservation organisations, have dominated technology transfer in the forestry sector. More recently, private establishments have been making inroads. Transfer of practices such as sustainable forest management (including reduced-impact logging, certification techniques and silvicultural practices), recycling, bioenergy technologies and agroforestry can contribute to the mitigation of carbon dioxide emissions. Establishing clear property rights, participatory forest management, use of financial incentives and disincentives, optimal use of regulations, and strengthening of monitoring and evaluating institutions are government actions that can promote their transfer.

Waste Management

Mitigation technologies are available and can be readily deployed. Roles of governments, private sector, and other organisations are changing. National governments can act as facilitators of municipal, private sector, and community-based initiatives. The private sector plays an increasing role, because meeting future waste management needs depends on expanded private investment. The involvement of community organisations is also increasing as the link between community support and project sustainability has become clear. It is important that projects emphasise the deployment of locally-appropriate technologies, and minimise the development of conventional large, integrated waste management systems in situations where lower cost, simpler alternatives can be used without compromising public health and environmental standards.

Human Health

An effective health system can help to address the adverse health impacts of climate change. Transfer of existing health technologies within and across countries can assist in achieving this objective. Raising public awareness of likely health impacts, close monitoring of health outcomes and training of health professionals are suitable actions. Thus, in terms of technology transfer there is a need to ensure that technologies are available at national and local levels for coping with any changes in the burden of disease that might be associated with climate change.

Coastal Adaptation

Technology transfer should focus on proven technologies for coastal adaptation, including indigenous solutions. Wetland restoration and preservation are examples of such proven adaptation technologies. Effective transfers of adaptation technologies are part of integrated coastal-management plans or programmes that utilise local expertise. Because coastal management is predominantly a public activity, technology transfer in coastal zones is driven by governments. Fragmented organisational and institutional relationships, and lack of access to financial means are major bafflers to the transfer of coastal adaptation technologies. Coastal adaptation programmes, based on strong partnership between existing institutions, can provide an effective response.

GLOSSARY

AISU	Advanced International Studies Unit (Battelle Pacific Northwest National Laboratory – US)
ARENA-ECO	The Ukrainian Agency for Rational Energy Use and Ecology
ASEAN	Association of Southeast Asian Nations
BASREC	Baltic Sea Region Energy Co-operation
BECon	The Beijing Energy Centre
BMZ	Federal Ministry for Economic Cooperation and Development (Germany)
CDM	Clean Development Mechanism (under UNFCCC)
CEL	Comision Ejecutiva Hidroelectrica del Rio Lempa
CEL	Comision Ejecutiva Hidroelectrica del Rio Lempa (El Salvador)
CENef	Centre for Energy Efficiency (Russia)
CFCs	Chlorofluorocarbons
CFLs	Compact fluorescent lamps
CHP	Combined heat and power
CO ₂	Carbon dioxide
CTI	Climate Technology Initiative
DOE	US Department of Energy (US)
DSM	Demand-side management
EAES	Environmentally Adapted Energy Systems (Sweden)
ECA	Export credit agency
EC-ASEAN	European Commission-ASEAN
EEN	Empresa Electricita del Norte (El Salvador)
ENEE	Empresa Nacional de Energía Eléctrica (Honduras)

EnEffect	The Bulgarian Centre for Energy Efficiency
ESCO	Energy service company
EST	Environmentally-sound technology
FDI	Foreign direct investment
FEWE	The Polish Energy Efficiency Centre
GEF	Global Environment Facility
GHG	Greenhouse gases
GNP	Gross national product
GTZ	German Agency for Technical Cooperation
HC	Hydrocarbon
HEECF	Hungary Energy Efficiency Co-Financing Fund
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IREDA	India Renewable Energy Development Agency
mtC	Metric tons of carbon-equivalent
MW	Megawatt
NGO	Non-governmental organisation
NREL	National Renewable Energy Laboratory (US)
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
OPIC	Overseas Private Investment Corporation (US)
PCF	Prototype Carbon Fund (World Bank)
PELP	Poland Efficient Lighting Project

PRODEEM	Programa de Desenvolvimento Energetico de Estados e Municipios (Brazil)
PV	Photovoltaic
PVGAP	Photovoltaic Global Approval Programme
RAEL	Renewable and Appropriate Energy Laboratory (University of California, Berkeley)
SEVE _n	The Czech Republic Energy Efficiency Centre
SICIP	Swedish International Climate Investment Programme
STEM	Statens Energimyndigheten (Energy Agency – Sweden)
TCAPP	Technology Co-operation Agreements Pilot Project (US)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	US Agency for International Development (US)
VAT	Value-added tax

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